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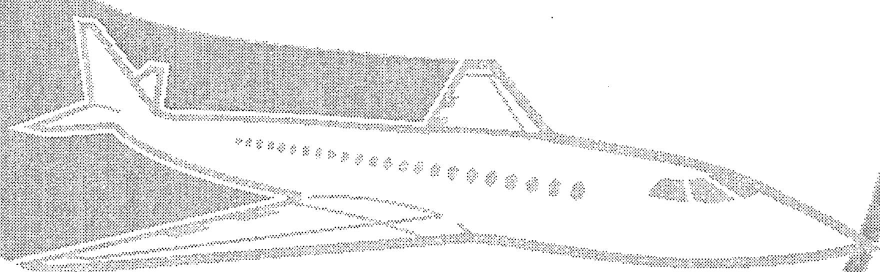
National Simulation Capability (NSC) Program Reduced Vertical Separation Minima (RVSM) Phase II Final Report



March 1996

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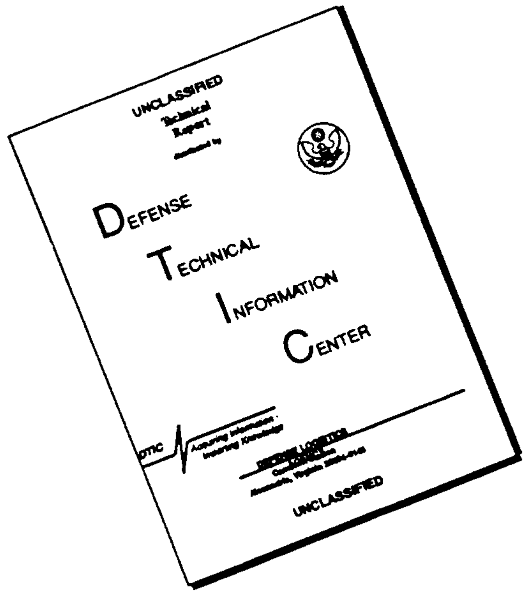

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16. Abstract

The Reduced Vertical Separation Minima (RVSM) experiment resulted from the conclusion reached by the North Atlantic System Planning Group to carry out studies aimed at achieving early implementation of RVSM in the North Atlantic (NAT) Region. RVSM is an approved International Civil Aviation Organization concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima (CVSM) of 2000 ft to 1000 ft, between flight levels 290 and 410, within a designated portion of the NAT Region.

RVSM Phase II studies were conducted in September 1994 at the New York Air Route Traffic Control Center (ARTCC) Dynamic Simulation Laboratory. Phase II investigated workload effects and the feasibility of transitioning aircraft to and from CVSM altitudes and from and to RVSM altitudes within radar sectors R65 and R86 under various traffic conditions. The study was also aimed at determining whether RVSM should be employed exclusively in sector R65 or in both sectors R65 and R86.

RVSM was instrumental in reducing controller workload when a majority of the traffic traveled eastbound. A decrease in workload was not observed while utilizing RVSM for westbound traffic. Post-run discussions and questionnaires also revealed some concerns over the implementation of RVSM. Frequently reported concerns were: separating RVSM-equipped and non-RVSM-equipped aircraft, difficulty maintaining data block separation during RVSM, and the possibility of aircraft flying into CVSM airspace at an RVSM altitude due to a temporary lack of communication.

Simulation results indicated that it is feasible to use domestic oceanic sectors R65 and R86 as RVSM transition airspace. However, controller training with RVSM is recommended. It is also recommended that New York ARTCC personnel develop guidelines to handle potential complications, such as communication failure.

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EXECUTIVE SUMMARY

The Reduced Vertical Separation Minima (RVSM) experiment resulted from the North Atlantic Systems Planning Group's conclusion to carry out studies aimed at achieving early implementation of RVSM in the North Atlantic (NAT) Region. RVSM is an approved International Civil Aviation Organization concept to reduce aircraft vertical separation from the Conventional Vertical Separation Minima (CVSM) of 2000 ft to 1000 ft, between flight levels 290 and 410, within a designated portion of the NAT Region. In the United States, RVSM studies are being conducted by the Federal Aviation Administration (FAA) Technical Center National Simulation Capability RVSM Experimentation Working Group.

RVSM Phase II studies were conducted in September 1994 at the New York Air Route Traffic Control Center (ARTCC) Dynamic Simulation (DYSIM) Laboratory. The study investigated workload effects and the feasibility of transitioning aircraft to and from RVSM altitudes and from and to CVSM altitudes within radar sectors R65 and R86 under various traffic conditions. The study was also aimed at determining whether RVSM should be employed exclusively in sector R65 or in both sectors R65 and R86. Experimental procedures, findings, and conclusions from the simulations were provided to the Air Traffic organizations in a continued effort to enhance the flexibility and efficiency of the National Airspace System, thereby providing user benefits.

During Phase II, 11 different traffic scenarios were investigated, with each scenario replicated 3 times. Scenarios varied by traffic flow (east or west), sector configuration (split or combined), separation minima (CVSM or RVSM), and RVSM authority (R65 or R65 and R86). Traffic scenarios were developed by Air Traffic Control Specialists and DYSIM training specialists based on DYSIM training tapes and actual recorded traffic flows. Currently-certified and active New York ARTCC controllers staffed Radar (R), Hand-off (H), and adjacent sector and facility positions. DYSIM training personnel staffed pseudo-pilot positions.

Extensive audio and video recordings provided objective data for all simulation runs. Guided post-simulation discussions, in conjunction with questionnaires, were used to gather subjective data. Dynamic workload probes were recorded at 15-minute intervals to assess the level of workload throughout each run.

During the simulation, higher overall (R and H combined) average workload levels were observed during the westbound traffic flows compared to the eastbound traffic. The simulation results indicated that RVSM was instrumental in reducing controller workload when a majority of the traffic traveled eastbound. A decrease in workload was not observed while utilizing RVSM for westbound traffic. This can be attributed to the fact that maintaining in-trail separation required more vectoring under RVSM compared to CVSM.

Post-run discussions and questionnaires revealed some major concerns over the implementation of RVSM. The most frequently-reported concern was separating RVSM-equipped and non-RVSM-equipped aircraft. Specifically, controllers were concerned with maintaining proper separation between RVSM and non-RVSM aircraft, maintaining awareness of RVSM aircraft converging with non-RVSM aircraft, and differentiating RVSM aircraft from non-RVSM

aircraft. Another frequently-reported concern was difficulty in maintaining data block separation during RVSM scenarios. The reduced separation created more data blocks in a closer proximity, resulting in greater overlap than during conventional separation. Finally, because of the occasionally unreliable communications in the R65/86 area, controllers mentioned the possibility of aircraft flying into CVSM airspace at an RVSM altitude due to a temporary lack of communication.

Although operational errors and average workload showed no difference between R65 and both R65 and R86 as transition airspace, the controllers preferred the latter. Simulation results indicated that it is feasible to use domestic oceanic sectors R65 and R86 for RVSM transitions. However, training is recommended to address the mix of aircraft and in-trail separation planning issues under RVSM. It is also recommended that guidelines be developed by New York ARTCC personnel to handle potential complications, such as communication failure.

1. INTRODUCTION

Reduced Vertical Separation Minima (RVSM) is an approved International Civil Aviation Organization (ICAO) concept. This concept reduces aircraft vertical separation from the Conventional Vertical Separation Minima[1] (CVSM) of 2000 ft to 1000 ft, between flight levels (FLs) 290 and 410, within a designated portion of the North Atlantic (NAT) Region.

The technical feasibility and cost benefits of establishing RVSM in the NAT Region have been the subject of many studies by affected ICAO member states. The results of these studies have led to ICAO planning for implementing reduced minimums in January 1998, with trials and verification scheduled to begin in January 1997. The Federal Aviation Administration (FAA) conducted a series of Air Traffic Control (ATC) simulations to assist Air Traffic (AT) organizations in identifying and defining the requirements for implementing RVSM in the United States.

The RVSM experiment described in this plan was conducted under the auspices of the FAA National Simulation Capability (NSC) Program. The NSC relied heavily on the expertise of controllers from the New York Air Route Traffic Control Center (ARTCC) oceanic area of specialization. NSC also relied on the expertise of the following organizations: Air Traffic Rules and Procedures Service (ATP-100), Air Traffic System Management (ATM-100), Air Traffic Plans and Requirements Service (ATR-300), Flight Standards (AFS-400), Program Analysis and Operations Research (ASD-400), Integrated Product Team for Oceanic (AUA-600), and the Simulation and System Integration Branch[2] (ACT-540).

RVSM Phase II simulations were designed to measure the effects of RVSM on controller workload in New York ARTCC radar sectors R65 and R86. Phase II investigated the following issues:

a. changes in controller workload levels as impacted by RVSM operations,
b. operational issues associated with RVSM operations in R65/86,
c. operational difficulties associated with controllers' ability to transition aircraft from and to RVSM and to and from CVSM within radar coverage, and
d. other issues related to reverting from RVSM rules to CVSM rules.

1.1 BACKGROUND

In late 1950, a need was identified to increase the prescribed vertical separation minimum (VSM) of 300 m (1,000 ft) due to the inaccuracy of pressure sensing barometric altimeters as altitudes increased. In 1960, FL 290 was selected as the vertical limit for the 300 m VSM, and a 600 m (2,000 ft) VSM was established for aircraft operating above FL 290. This vertical limit was chosen based on the operational ceiling of the aircraft at that time. In 1966, although FL 290 was established as the vertical changeover level on a global basis, consideration was already being

[1] CVSM - 2,000 ft VSM above FL 290 up to FL 600, inclusive.
[2] Formally ACD-350, Simulation and Human Factors Branch.

given to the application of RVSM above FL 290 on a regional basis. Consequently, ICAO provisions stated that RVSM could be applied under specific conditions and within designated portions of airspace. To support this provision, ICAO recognized that a thorough assessment of the risk associated with reducing the VSM would be required.

In 1980, the ICAO Review of the General Concept of Separation Panel (RGCSP) concluded that the potential benefits of reducing vertical separation above FL 290 to 300 m outweighed the cost and time involved. Member states were encouraged to conduct the necessary evaluations. In 1982, studies coordinated by the RGCSP were initiated to evaluate reducing the VSM above FL 290. The studies were carried out by Canada, Japan, member states of EUROCONTROL (France, the Federal Republic of Germany, the Netherlands, and the United Kingdom), the Union of Soviet Socialist Republics, and the United States. In December 1988, the RGCSP reviewed the results.

Using a Target Level of Safety of 2.5×10^{-9} fatal accidents per aircraft flight hour, the RGCSP concluded that a 300 m VSM above FL 290 was technically feasible. Contemporary height-sensing systems could be built, maintained, and operated so that the expected performance is consistent with the safe implementation and use of a 300 m VSM above FL 290. In reaching this conclusion on the technical feasibility, the panel found that it would be necessary to establish the following system features:

a. air-worthiness performance requirements embodied in a comprehensive minimum aircraft system performance specification (MASPS) for all aircraft utilizing the reduced separation,
b. new RVSM operational procedures, and
c. a comprehensive means of monitoring the safe operation of the system.

The RGCSP identified the NAT Region as an area where early implementation of RVSM was possible because of the traffic patterns and equipment requirements for the aircraft population. On this basis, and in view of the substantial benefits, the North Atlantic System Planning Group, at its 26th meeting, agreed to carry out studies aimed at achieving early implementation of RVSM in the NAT Region. Worldwide and regional provisions concerning the implementation of RVSM were finalized for application in November 1992[3]. Thus, reduced vertical separation may be implemented within Minimum Navigation Performance Specification (MNPS) airspace (see Figure 1) and in other defined transition areas in the ICAO NAT Region.

The FAA NSC Program originally planned a two-phase study to investigate and measure the effects of RVSM implementation in the MNPS and adjacent radar-controlled airspace under NY ARTCC control. An additional phase was designed to investigate RVSM implementation in the Western Atlantic Route System (WATRS) area under Miami ARTCC control. In Phase III, aircraft eventually traversing WATRS airspace will be permitted to exit or enter the MNPS airspace from the south at RVSM altitudes, and the associated transition would occur in Miami ARTCC airspace.

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[3] Manual on implementation of a 300 m (1000 ft) VSM between FL 290 and FL 410 inclusive is ICAO Doc. No. 9574-AN/934, dated 1992.

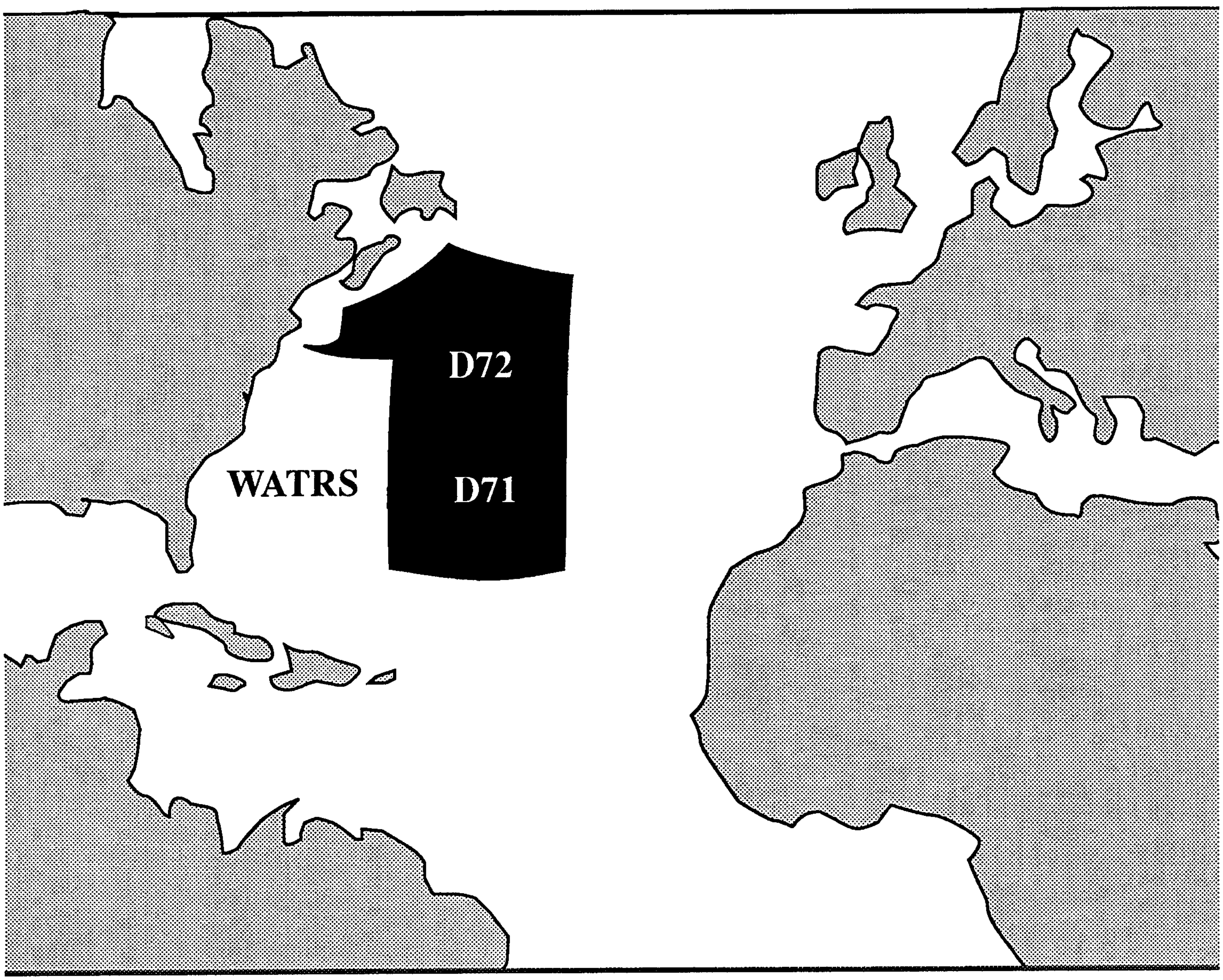

FIGURE 1. MINIMUM NAVIGATION PERFORMANCE SPECIFICATION/
REDUCED VERTICAL SEPARATION MINIMA (RVSM) AIRSPACE

Phase I testing was completed in January 1994. This phase was a study of the transition of westbound aircraft from RVSM to CVSM before leaving RVSM/MNPS airspace (Figure 2). There was an exception for aircraft that entered radar coverage adjacent to RVSM/MNPS airspace or Canadian airspace (this was either MNPS or radar coverage). Results indicated that transition in non-radar airspace was feasible; however, radar transitions were recommended (Seeger, 1995).

Phase II focused on transitions in domestic oceanic airspace (see Figure 3). Aircraft were permitted to exit or enter the MNPS airspace from the West at RVSM altitudes, and the associated transitions would occur within the adjacent radar-controlled sectors, R65 and R86, under the control of the New York ARTCC.

1.2 PURPOSE

The long range AT forecast for the NAT Region estimates that air traffic will double by the year 2010[4]. The reduction of vertical separation in the MNPS airspace, NAT Region, between FL 290 and FL 410 inclusive, would theoretically accommodate such a projected increase in air traffic. This enhancement in system capacity would provide for a more efficient use of the available airspace and result in significant improvements in flight economy.

The most difficult problem with operating under RVSM in the MNPS airspace will probably be the transition of aircraft to CVSM. Additionally, the procedures for transition may differ based upon the geographical restrictions. ATC procedures for potential RVSM transition areas within the NAT Region and adjacent ICAO Regions therefore need to be defined prior to the implementation of RVSM. Accordingly, this experiment evaluated procedures used by controllers when transitioning aircraft to and from RVSM and from and to CVSM.

The first objective of the RVSM experiments was to analyze the geographical areas where RVSM transitions could safely occur and identify the problems associated with that transition. The second objective was to address changes in controller workload caused by increased flight operations. Part of the second objective was to study the impact of weather-related problems and contingencies that cause aircraft deviations on controller workload.

The NSC RVSM experiment and associated activities were designed to provide AT Service Organizations, especially the International Procedures Branch (ATP-140), with the vital human performance information needed to define RVSM implementation procedures. This experiment represented a critical step in assessing current and projected New York ARTCC oceanic ATC system capabilities. The results of this study will be closely coordinated and shared with all NAT ATC provider states to help facilitate the development of a unified implementation plan.

[4] Agenda Item 2, Working Paper 131, presented at the Limited North Atlantic (COM/MET/RAC) Regional Air Navigation Meeting held in Cascais, Portugal, in November 1992.

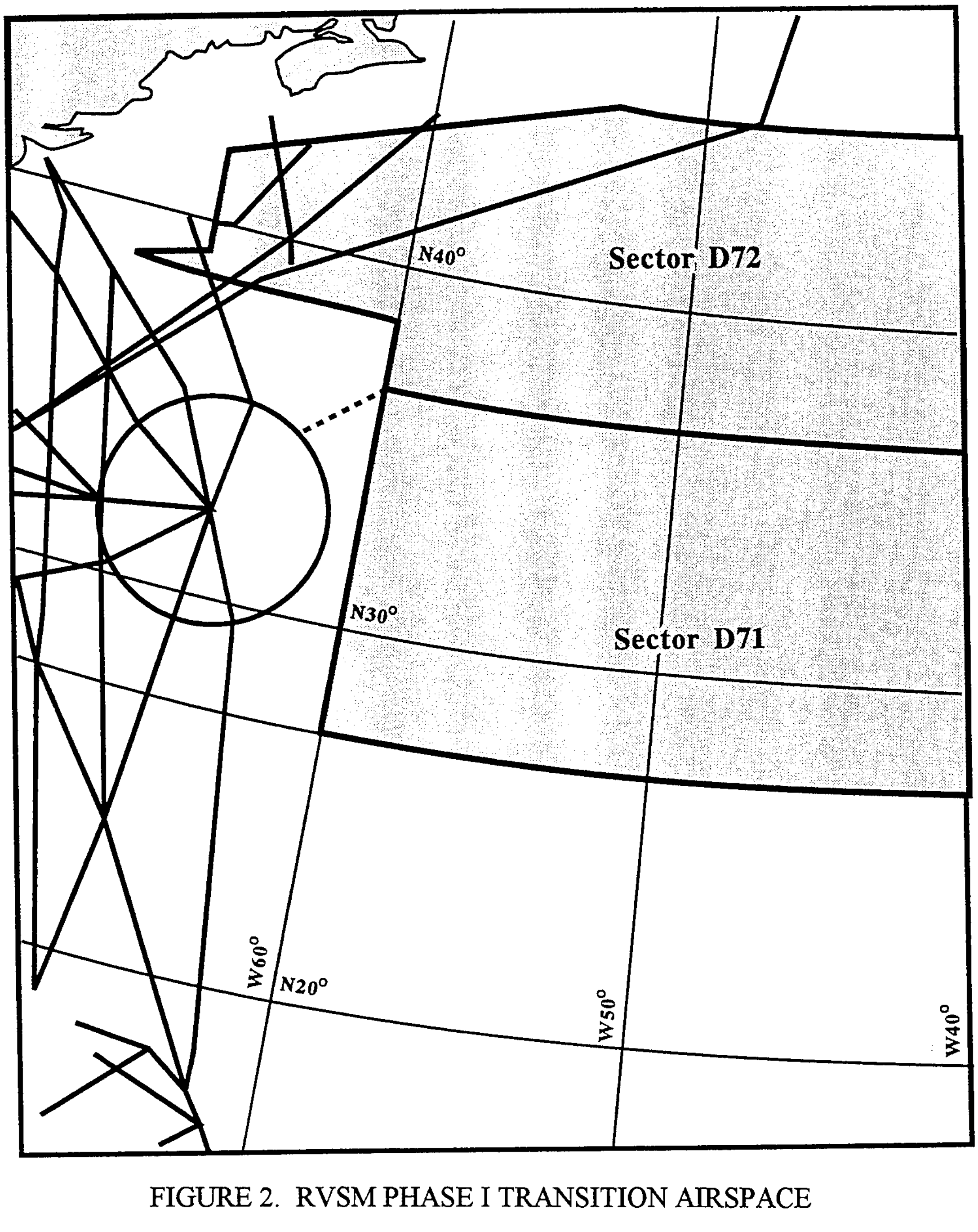

FIGURE 2. RVSM PHASE I TRANSITION AIRSPACE

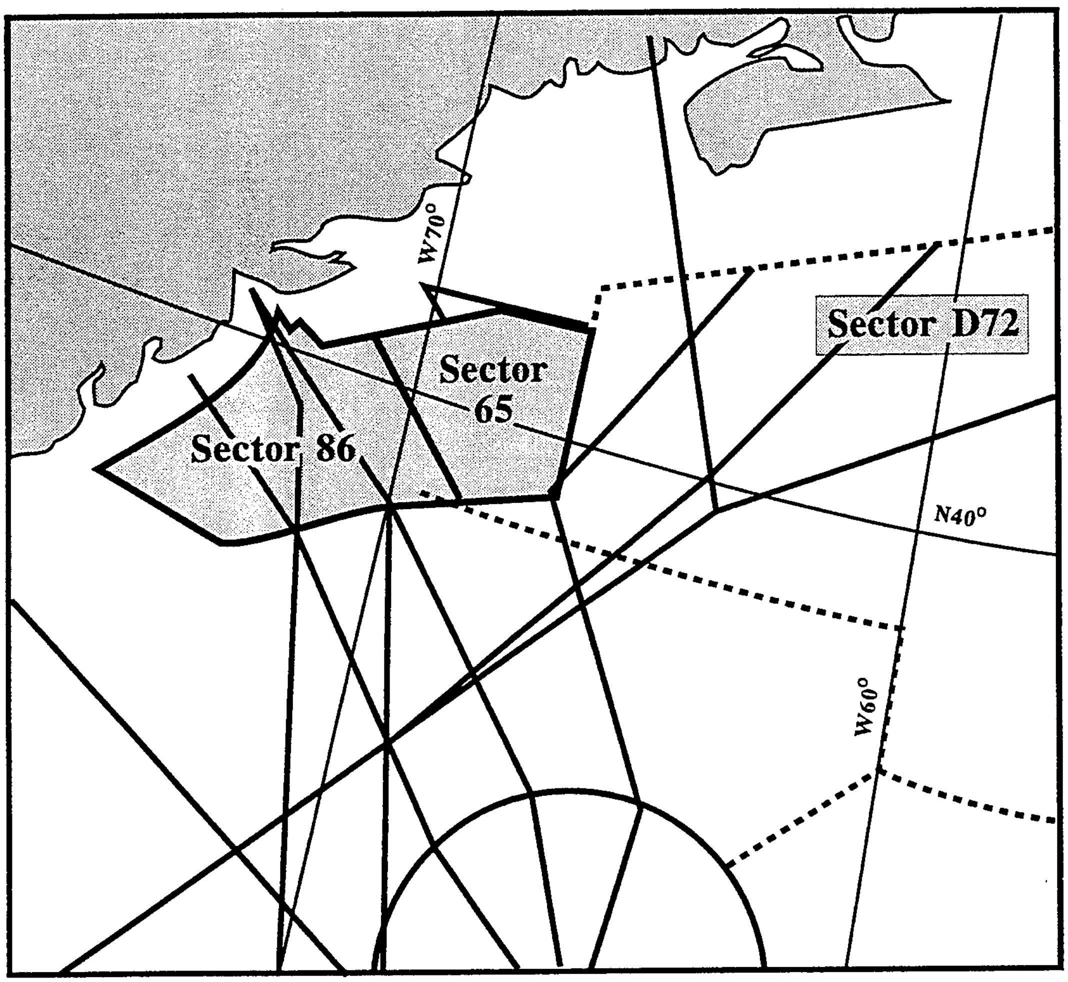

FIGURE 3. RVSM PHASE II TRANSITION AIRSPACE

2. METHOD

Simulations were conducted in the New York ARTCC Dynamic Simulation (DYSIM) Laboratory from September 7 through 16, 1994. The immediate physical environment realistically simulated the New York ARTCC radar sectors R65 and R86, including the available equipment and communication interfaces. This experiment incorporated real-time ATC simulations, designed to evaluate workload when controllers provided separation, and other ATC services in designated domestic oceanic radar controlled transition airspace areas. Each simulation parameter was designed to enable valid comparisons between current CVSM operations and RVSM-planned operations. Thus, overall traffic load was held relatively constant for each simulation run. Only separation rules and constraints were varied for each condition.

During the simulation, RVSM-approved aircraft were permitted to transition to and from RVSM and from and to CVSM in radar controlled airspace. The transition occurred when RVSM-approved aircraft entered the radar sectors R65 and R86, after which two-way direct very high frequency (VHF) communication was established. The RVSM experiment adhered to the following international guidelines as a basis for developing each simulation scenario.

a. RVSM was affected coincident with MNPS airspace and in defined transition areas.

b. The transition to and from reduced VSM was affected in transition areas.

c. The transition areas were:

   1. defined as Class A airspace; accordingly, aircraft proceeding to and from MNPS airspace were authorized to transition to and from 1,000 ft VSM;

   2. contained within horizontal limits determined by provider states, either individually or in conjunction;

   3. adjacent to, overlapping with, or contained within MNPS airspace;

   4. within radar coverage using direct controller-pilot communications wherever practical; and

   5. contained within the vertical limits of FL 290 to FL 410, inclusive.

d. When operating within transition areas, RVSM was applied between aircraft approved for such operations[5] when transitioning to and from MNPS airspace.[6]

2.1 PARTICIPANTS

Four currently-certified controllers from the New York ARTCC (referred to as Controllers A, B, C, and D throughout the document) staffed the simulated radar sectors R65 and R86. An additional controller, with previous oceanic sector D72 experience, staffed a ghost control position handling all adjacent sector and facility coordination.

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[5] Refer to FAA document # 91-RVSM entitled *Interim Guidance Material on the Approval of Operators/Aircraft for RVSM Operations.*

[6] Agenda Item 2, Working Paper 131, presented at the Limited North Atlantic (COM/MET/RAC) Regional Air Navigation Meeting held in Cascais, Portugal, in November 1992.

Two pseudo-pilot positions were staffed by DYSIM training specialists. Another controller provided technical support for the pseudo pilots. Two technical observers (T/Os) recorded workload ratings and made judgments about operational effectiveness and problems. It was anticipated that implementing RVSM in New York ARTCC airspace would affect ATC services at Boston Center. Therefore, Boston Center personnel were invited to participate in the simulation exercises. They provided one current and active radar controller that participated as a T/O. The other T/O was from the NY ARTCC. Five additional support personnel were provided by ACT-540 (formerly ACD-350)[7], from the FAA Technical Center.

2.1.1 Background Survey

A background survey was conducted to collect basic demographic data and information about the participant's opinions regarding high workload situations. Data from the background survey were used as a baseline for comparison with survey responses collected throughout the simulation.

The average age of the five participating controllers was 37 as shown in Table A1 (Appendix A). The controllers had an average of 7 years ATC experience. In addition, they had the following average experience:

a. Full Performance Level, 5 years;

b. NAT Full Performance Level Oceanic Controller, 6 years; and

c. ATC Trainer, 7 years.

The controllers and T/Os were asked what they would change about the current elements in the oceanic radar area, if they could make a change. Responses indicate that better radar coverage, frequency coverage, and weather display capabilities were desired. The participants acknowledged that frequency congestion, especially pilots talking over one another and background noises, was the most significant problem that prevented them from maintaining an orderly and expeditious traffic flow. Other difficulties included: bad frequency coverage at lower FLs and at the frequency boundaries, too many telephone calls from Aeronautical Radio, Incorporated (ARINC), and bad weather.

2.2 EQUIPMENT CONFIGURATION

2.2.1 Dynamic Simulation Laboratory

The New York ARTCC DYSIM Laboratory provided controllers with a realistic simulated radar environment. All the planned scenarios were stored as files on a DYSIM tape. Simulated (SIM) radar targets were generated using the Simulation Start action on the aircraft in the DYSIM files. A SIM target represents the radar trails of a maneuvering aircraft.

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[7] Support personnel were also provided by ACD-340, which, due to FAA reorganization, became ACT-200 and ACT-510.

Primary and beacon radar data were generated for each SIM target and processed by the Multiple Radar Processing function of the National Airspace System in a manner similar to normal radar data. The SIM flight data block contained the SIM flight identification, magnetic heading, beacon code, and altitude. The position of the SIM radar data was automatically updated approximately every 10 seconds.

The SIM radar target maneuvered automatically, based on route segments from a flight plan and by operator input into a computer readout display (CRD), to depict actual aircraft operations. The CRD allowed the pilot to alter 10 aspects of an aircraft flight (altitude, routing, rate of climb, etc.). The result was a totally simulated flight that could exercise almost all functions as if there was a paired flight plan and flight data processing with flight progress strip preparation capability.

2.2.2 Voice Communication System

The voice communication system was a Robert Thomas Smith (RTS) Systems Model CS9500 Digital Intercom System. The RTS CS9500 is a programmable intercommunication system that maintains high quality speech characteristics utilizing a four-wire, central, non-blocking matrix design. Programming was provided by an MS-DOS-based package called CSEdit, operating on a 486 laptop personal computer connected to the matrix through the serial communication port.

Each controller was given a four-wire belt pack unit that provided communication functionality similar to that found on the floor of the center, exclusive of a shout line. Voice communication between the controllers and pseudo pilots was a combination of party lines and point-to-point communication. The matrix was programmed to the specifications required by the various experiment configurations.

2.2.3 Audio and Video Recording Rack

An extensive audio and video system was used to collect data during each simulation run. Two black and white, low-light micro cameras recorded each sector individually. A third camera recorded an overall view of the simulation. The video was recorded in Super VHS format on 2-hour tapes, which were stamped with National Television System Committee linear time code for synchronous playback purposes.

Seven separate audio signals were recorded, four from the wireless microphones worn by each controller and three directly from the intercom system. The audio signals were mixed on a Tascam M2516 audio mixing board and recorded on the hi-fi audio channels of the video tapes according to the corresponding camera views.

2.3 SCENARIOS

All scenarios were developed in conjunction with a New York ARTCC ATC specialist. The scenarios were developed on the basis of flight plans extracted from Data Analysis and Reduction Tool (DART) runs of System Analysis and Recording (SAR) tapes dated 03/12/94, 05/19/94, and 5/20/94, and from DYSIM training files.

Operationally, it takes an aircraft approximately 30 minutes or less to traverse sector R65 or R86. This estimate was the basis for establishing a one-hour run time for each scenario. One hour allowed adequate time for aircraft to pass through the simulated sectors. Eleven scenarios were developed that varied according to the following parameters:

a. eastbound versus westbound traffic flows,

b. R65/R86 split versus R65/R86 combined,

c. RVSM clearances in R65 airspace only versus RVSM clearances in both sectors R65 and R86,

d. random route traffic versus incoming Minimum Time Track (MTT) traffic over JOBOC or SLATN,[8] and

e. contingencies:

   1. merge of traffic at KENDA,[9]

   2. restricted areas became active (hot), and

   3. communication failure over SLATN (for about 20 miles).

The parameters for each scenario are described in Table 1. The number of scripted pilot events and the number of aircraft in each scenario are listed in Table 2. These scenarios were selected by New York ARTCC personnel and the FAA Headquarters Organization, ATP-140, as the minimum conditions required to adequately investigate all the pertinent RVSM issues for the New York ARTCC oceanic domestic radar sectors.

2.4 EXPERIMENTAL PROCEDURES

Two sector configurations were used during the 8 days of simulation. Eight of the scenarios were run over 6 days with Configuration 1 (see Figure 4). The remaining three scenarios were run with Configuration 2 for 2 days (see Figure 5). All the scenarios were repeated three times, regardless of configuration. Both configurations had Radar (R) and Hand-off (H) control positions, two pseudo-pilot positions, one or two T/Os, and a ghost or "D" control position. Sectors R65 and R86 were combined on one display for Configuration 1. For this configuration, three controllers were randomly assigned to the R and H control positions. For Configuration 2, the sectors were displayed on separate Plan View Displays. Four controllers were randomly assigned to the two R and two H control positions. The ghost or D position was always staffed by the same controller.

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[8] JOBOC and SLATN are coordination fixes corresponding to N40°07.0' W67°00.0' and N39°07.0' W67°00.0' respectively.

[9] KENDA is a coordination fix corresponding to N39°21.2' W70°30.1'

TABLE 1. SUMMARY OF SCENARIOS

Scenario	Traffic Flow	R65/86 Configuration	RVSM Authority	Contingencies/Traffic Flow
NE01	East	Split	R65	-
NE02	East	Split	R65	D72 Com. Failure
NE03	East	Split	R65 & 86	-
NE04	East	Combined	R65 & 86	-
NE05	East	Combined	R65	-
NE06	East	Combined	R65	D72 Com. Failure
ACTUAL	East	Combined	CVSM	-
SWKENDA	West	Combined	R65 & 86	KENDA Merge/D72 Com. Failure
SWRVSM	West	Combined	R65 & 86	-
SWMTT	West	Combined	R65 & 86	MTT (JOBOC & SLATN)
SWBASE	West	Combined	CVSM	-

TABLE 2. FREQUENCY OF PILOT EVENTS AND AIRCRAFT

Scenario	Pilot Events	Number of Aircraft
NE01	11	40
NE02	14	41
NE03	12	35
NE04	11	27
NE05	12	24
NE06	09	27
ACTUAL	04	27
SWKENDA	08	30
SWRVSM	08	33
SWMTT	09	33
SWBASE	09	34

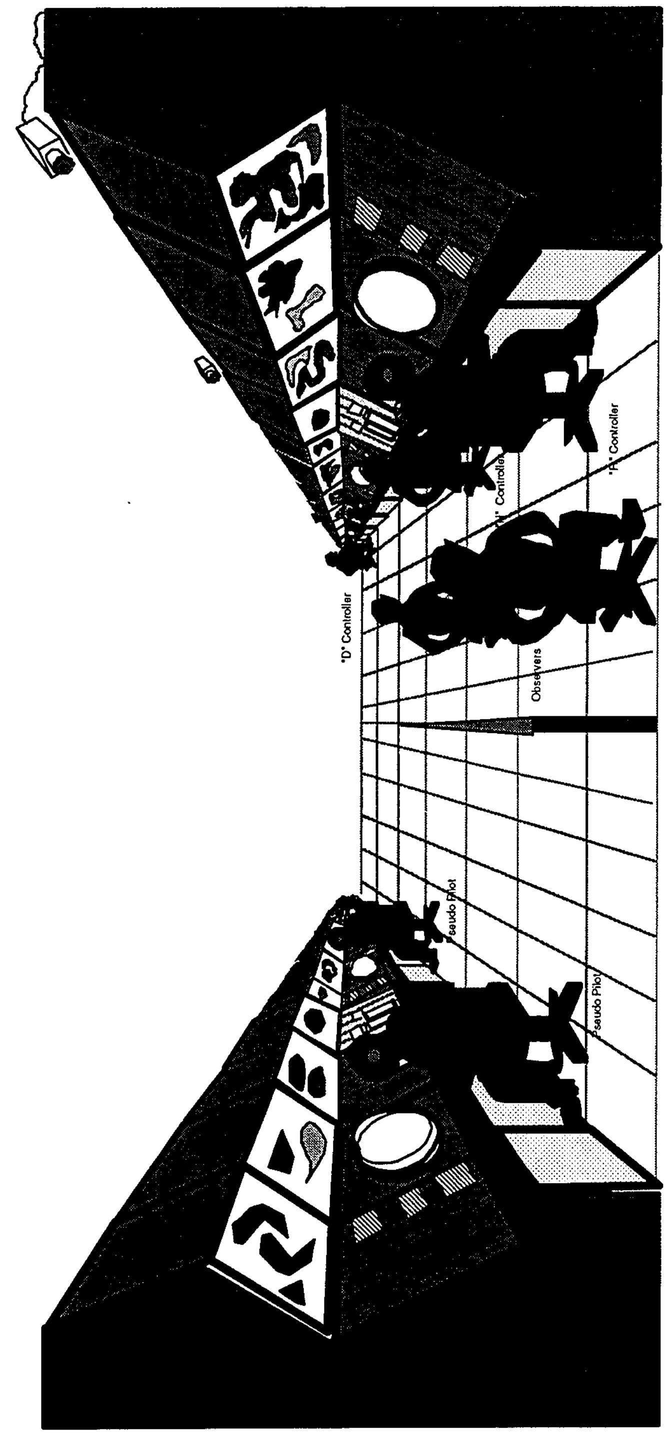

FIGURE 4. DYNAMIC SIMULATION LABORATORY: CONFIGURATION 1

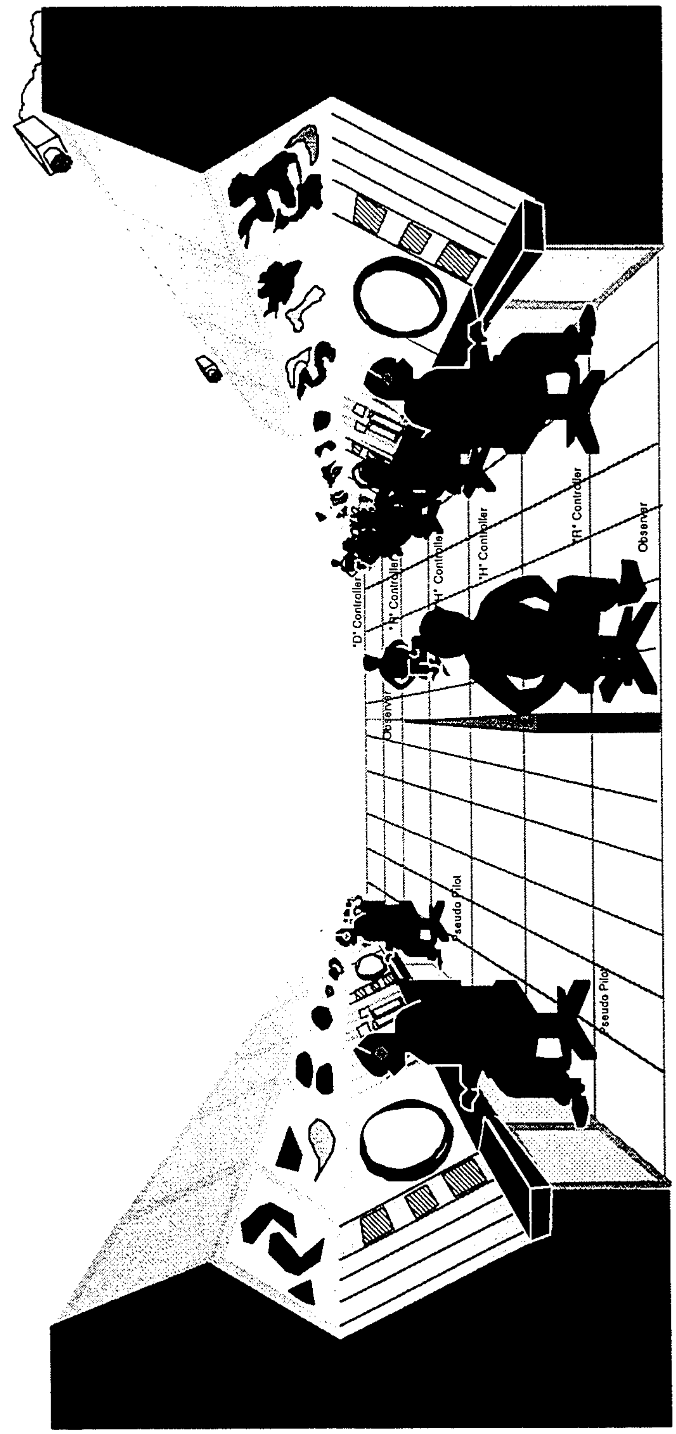

FIGURE 5. DYNAMIC SIMULATION LABORATORY: CONFIGURATION 2

2.4.1 Controller Assignment

Daily schedules for the simulation are listed in Tables 3 and 4. Four scenarios were run daily except for September 13, which had 5. Each cell in Tables 3 and 4 lists the scenario and controllers in their respective positions. Scheduled run times for scenarios 4 through 11, which were run with Configuration 1, are shown in Table 3. For example, on September 7 at 4:00 p.m., scenario NE04 was run with controller A working the H position and controller B working the R position.

TABLE 3. SCHEDULE FOR CONFIGURATION 1

Date Position Local Time	Sept. 7 H R	Sept. 8 H R	Sept. 9 H R	Sept. 12 H R	Sept. 15 H R	Sept. 16 H R
3:00 p.m.	Brief	Brief	Brief	Brief	Brief	Brief
4:00 p.m.	NE04 A B	NE05 A B	SWRVSM C A	NE04 C A	SWKENDA B C	SWKEND A C A
5:00 p.m.	Break/ Debrief	Break/ Debrief	Break/ Debrief	Break/ Debrief	Break/ Debrief	Break/ Debrief
5:30 p.m.	NE05 B C	NE04 B C	SWKEND A A B	SWRVSM A B	ACTUAL C A	SWBASE A B
6:30 p.m.	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch
7:30 p.m.	NE06 C A	SWBASE C A	ACTUAL B C	SWMTT B C	SWRVSM B C	SWBASE B C
8:30 p.m.	Break/ Debrief	Break/ Debrief	Break/ Debrief	Break/ Debrief	Break/ Debrief	Break/ Debrief
9:15 p.m.	ACTUAL A B	NE06 A B	SWMTT C A	NE05 C A	NE06 B C	SWMTT A B
10:15 p.m.	Debrief	Debrief	Debrief	Debrief	Debrief	Debrief
11:00 p.m.	END	END	END	END	END	END

TABLE 4. SCHEDULE FOR CONFIGURATION 2

Date	Sept. 13				Sept. 14			
Sector	R65		R86		R65		R86	
Position	H	R	H	R	H	R	H	R
Local Time								
3:00 p.m.	Brief				Brief			
3:30 p.m.	NE01				NE03			
	A	B	C	D	A	B	C	D
4:30 p.m.	Break				Break			
5:00 p.m.	NE02				NE01			
	D	C	B	A	D	C	B	A
6:00 p.m.	Break				Break			
6:30 p.m.	NE03				NE02			
	D	C	B	A	D	C	B	A
7:30 p.m.	Lunch				Lunch			
8:15 p.m.	NE01				NE03			
	C	A	D	B	C	A	D	B
9:15 p.m.	Break				Break			
9:45 p.m.	NE02				a			
	A	B	C	D				
10:45 p.m.	Debrief				Debrief			
11:00 p.m.	END				END			

[a] Time allotted in case of system failures.

The scheduled run times for scenarios 1 through 3 are shown in Table 4. For example, on September 13, scenario NE01 was run with controller A working the H position and controller B working the R position for sector R65, and controller C working the H position and controller D working the R position for sector R86.

2.4.2 Data Collection

All simulation participants filled out background forms and post-run questionnaires and participated in recorded debriefing sessions. Background forms and post-run questionnaires are provided in Appendix B. In addition, each run was audio- and video-recorded (refer to Sections 2.2.2 and 2.2.3).

The simulation data were collected via the following media:

a. automated recording of Host data via SAR tapes;

b. real-time observations of critical controller actions recorded by trained T/Os throughout each simulation run;

c. real-time, interval (approximately every 15 minutes), controller, workload ratings made by the T/Os;

d. real-time, interval, controller, workload ratings obtained by having the T/O prompt a verbal report from all controllers at 15-minute intervals throughout each simulation run;[10] and

e. controller and T/O responses to questionnaires and structured interviews conducted after each simulation run.

Controllers gave self evaluations of workload while the T/Os gave their perception of the controller workload during and after each run. Controllers and T/Os independently made four interval workload ratings during each run and an overall evaluation of workload after each run. In addition, T/Os gave interval ratings for controllers on flight strip management, communication and coordination, and traffic management. Ratings were based on a 10-point scale. For workload, 1 indicated very low workload and 10 indicated very high workload. For the other factors, 1 indicated the controller performed to FAA Order 7110.65 specifications very easily, and 10 indicted the controller did not perform to specifications.

Two T/Os independently rated controller workload at the end of each scenario. If the sectors were combined, one rated the R position, while the other rated the H position. When the sectors were split, one T/O rated the R and H positions for sector R86, while the other T/O rated both control positions for sector R65. However, during the first day, there was only one T/O available to observe both control positions.

3. RESULTS

For the purpose of data analysis, the 11 traffic scenarios were divided into 9 different conditions based on sector, RVSM authority, direction of traffic, and track type. Comparative analyses of both the T/O and self-reported ratings were grouped into four traffic relationships:

a. comparison of all nine traffic conditions,

b. comparison of eastbound and westbound RVSM traffic,

c. comparison of RVSM versus CVSM within eastbound traffic conditions, and

d. comparison or RVSM versus CVSM within westbound traffic conditions.

The 11 scenarios listed in Table 1 are grouped into the 9 different traffic conditions shown in Table 5.

3.1 INTERVAL DATA ANALYSIS

3.1.1 Analysis Approach

All four comparisons were performed on workload ratings that were reported during each run by controllers and T/Os. In addition, tests were performed on other ratings that observers recorded

[10] This procedure, called the Air Traffic Workload Input Technique (ATWIT), is an FAA-validated technique used for the continual assessment of controller workload.

TABLE 5. TRAFFIC CONDITIONS

Condition	Scenario(s)	Separation
1	Actual	CVSM
2	NE06 & NE05	RVSM
3	NE01 & NE02	RVSM
4	NE04	RVSM
5	NE03	RVSM
6	SWRVSM	RVSM
7	SWKENDA	RVSM
8	SWMTT	RVSM
9	SWBASE	CVSM

during the simulation. All tests were performed with a significance level of $\alpha = 0.05$. All data were tested for homogeneity of variance using the Barlett-Box test. A one-way analysis of variance (ANOVA) with a covariate (number of aircraft) was used to analyze interval data. The choice of the number of aircraft as a covariate was based on prior literature, indicating a strong relationship between workload and the number of aircraft (Costa, 1993; Hurst & Rose, 1978 a, b; Kopardekar, 1995; Laurig, Becker-Biskaborn, & Reiche, 1971; Stein, 1985; Zeier, 1994). A partial correlation was calculated to evaluate the relationship between the controller and T/O ratings adjusted for the number of aircraft.

3.1.2 Technical Observer and Controller Workload Ratings

No statistically significant differences were found between controller and T/O ratings for either control position. Controller and T/O ratings had a statistically significant high positive correlation ($r_H = 0.58$) and ($r_R = 0.76$).

3.1.3 Technical Observer-Reported Controller Workload Ratings

The average controller workload rating, as perceived by the T/Os, are displayed in Figure 6. The following subsections provide a comparative analysis of these ratings.

3.1.3.1 Workload for All Traffic Conditions

Workload ratings reported by the T/Os for all nine traffic conditions were analyzed. Workload ratings for both the R, $F(8, 158) = 2.2$, and H, $F(8, 151) = 3.09$, controllers were statistically significant.

The H controller's average workload for eastbound CVSM traffic was significantly higher than for westbound CVSM traffic, $t(151) = -3.96$. Condition 1 shows that the average H controller workload was 5.75 and Condition 9 shows that the average H controller workload was 3.36 (see Figure 6).

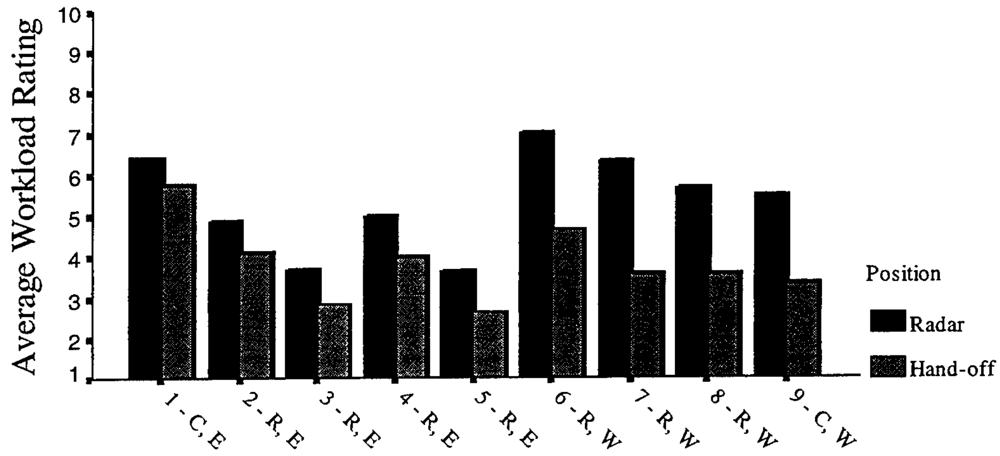

FIGURE 6. AVERAGE TECHNICAL OBSERVER-REPORTED INTERVAL CONTROLLER WORKLOAD

Significant differences in average workload ratings were not found between conditions for the R controller except between westbound Conditions 9 and 6, $t(158) = 2.08$, and Conditions 9 and 7, $t(158) = 3.24$.

3.1.3.2 Workload for Eastbound and Westbound RVSM Traffic

No statistically significant differences were found between the average workload ratings for eastbound and westbound RVSM traffic for either control position (R controller $\mu_{east} = 4.18$, $\mu_{west} = 6.30$ and H controller $\mu_{east} = 3.28$, $\mu_{west} = 3.94$). Moreover, the overall average (R and H combined) workload was not significantly different between eastbound and westbound traffic.

3.1.3.3 Workload for CVSM and RVSM with Eastbound Traffic

There were statistically significant differences in the average H controller workload among eastbound traffic conditions, $F(4, 108) = 2.62$. There were also significantly different average workload ratings for the CVSM eastbound condition compared to each RVSM eastbound condition for the H controller: Conditions 1 and 2, $t(151) = -2.06$; Conditions 1 and 3, $t(151) = -3.32$; Conditions 1 and 4, $t(151) = -2.50$; and Conditions 1 and 5, $t(151)= -2.83$. The highest average workload observed under CVSM separation is shown in Figure 6.

There were no statistically significant differences between the average R controller workload for eastbound CVSM traffic and any of the RVSM traffic. Although not statistically different, Figure 6 shows a slight increase in R controller average workload under CVSM compared to RVSM.

3.1.3.4 Workload for CVSM and RVSM with Westbound Traffic

There were statistically significant differences in the average controller workload between westbound CVSM and RVSM traffic for both the H, $F(3, 42) = 3.23$, and R, $F(3, 43) = 9.45$, controllers. The average workload rating under CVSM westbound traffic ($\mu = 3.36$) was lower than for any of the RVSM westbound traffic conditions.

Average workload ratings for the H controller were significantly different between Conditions 9 and 6, $t(42) = 2.66$. Average R controller workload ratings were significantly different between Conditions 9 and 6, $t(43) = 2.64$, and Conditions 9 and 7, $t(43) = 4.59$. The lowest average workload rating for the R controller was observed during CVSM west bound traffic ($\mu = 5.50$).

3.1.4 Control Duties

No significant differences were found between average ratings given for flight strip management, traffic management, or communication and coordination. Average values ranged from 4.50 to 5.91.

3.1.5 Self-Reported Workload Ratings

The average self-reported controller workload ratings are displayed in Figure 7. The following subsections provide a comparative analysis of these ratings.

3.1.5.1 Workload for All Traffic Conditions

Self-reported average workload ratings for both the H and R control positions did not show any significant differences between traffic conditions. However, Figure 7 shows that the highest average H controller workload was observed under Condition 1, and the lowest average workload was observed under Condition 5. The highest average R controller workload was observed under Condition 6, and the lowest average workload was again observed under Condition 5.

3.1.5.2 Workload for Eastbound and Westbound RVSM Traffic

Average workload ratings for both the H and R control positions did not show any significant differences between eastbound and westbound traffic under RVSM separation. Moreover, the overall average workload ratings were not significantly different for eastbound and westbound RVSM traffic conditions.

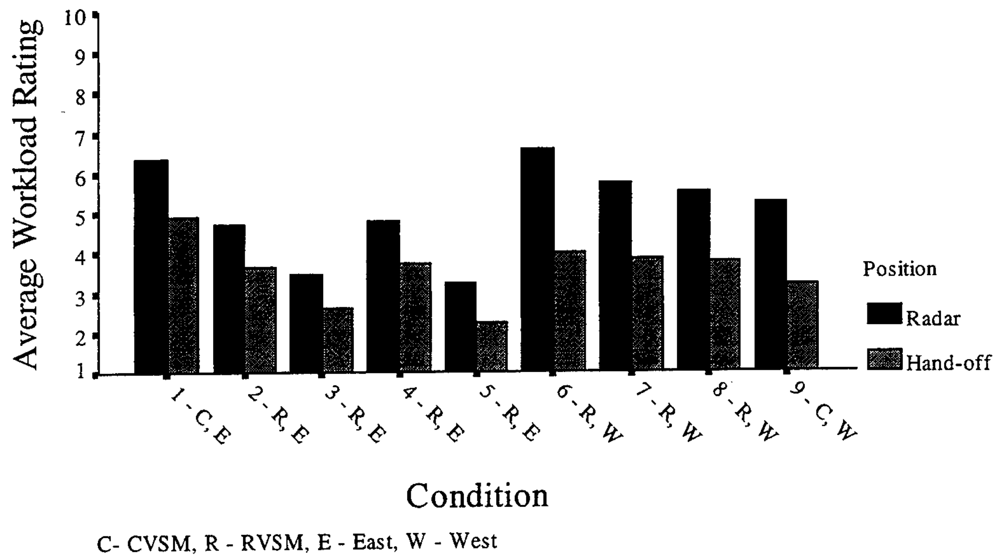

FIGURE 7. AVERAGE SELF-REPORTED INTERVAL CONTROLLER WORKLOAD

3.1.5.3 Workload for CVSM and RVSM Eastbound Traffic

Average controller workload ratings for both the H and R control positions did not show any significant differences between CVSM and RVSM eastbound traffic conditions. However, the highest average workload values for both the R and H positions were observed under Condition 1.

3.1.5.4 Workload for CVSM and RVSM Westbound Traffic

There were statistically significant differences between average workload values for CVSM and RVSM westbound traffic for the R controller, $F(3, 43) = 7.36$, but not for the H controller. Average workload ratings were significantly different between Conditions 9 and 6, $t(43) = 2.42$, and Conditions 9 and 7, $t(43) = 4.09$. The lowest average workload ratings for both control positions were observed during CVSM westbound traffic.

3.2 POST-RUN DATA ANALYSIS

3.2.1 Analysis Approach

All four comparisons were also performed on post-run T/O and controller workload ratings. All tests were performed with a significance level of $\alpha = 0.05$. All data were tested for homogeneity of variance using the Levene test. If this test was significant, the nonparametric Kruskal-Wallis (χ^2) or Mann-Whitney U test statistic is reported. If the Levene test was not significant, a one way ANOVA was performed. Post hoc tests were then performed using the Tukey Honestly Significant Difference (HSD) test. A nonparametric statistical correlation (Spearman rank) was calculated to evaluate the relationship between the controllers' and observers' ratings.

3.2.2 Technical Observer and Controller Workload Ratings

No significant difference was found between self-reported and T/O-reported post-run workload ratings for the R controller. R controller workload values had a highly significant positive correlation ($r_s = 0.48$). A significant difference was found between self-reported and T/O-reported workload values for the H controller, $t(92) = 6.59$. H controller workload ratings only had a correlation of $r_s = 0.24$, which was not significant at the $\alpha = 0.05$ level. The average T/O H controller rating was higher ($\mu = 7.02$) than the average self-reported workload rating ($\mu = 4.95$).

3.2.3 Technical Observer-Reported Controller Workload Ratings

The T/O-reported R and H controller average workload ratings for each traffic condition are displayed in Figure 8. The following subsections provide a comparative analysis of these ratings.

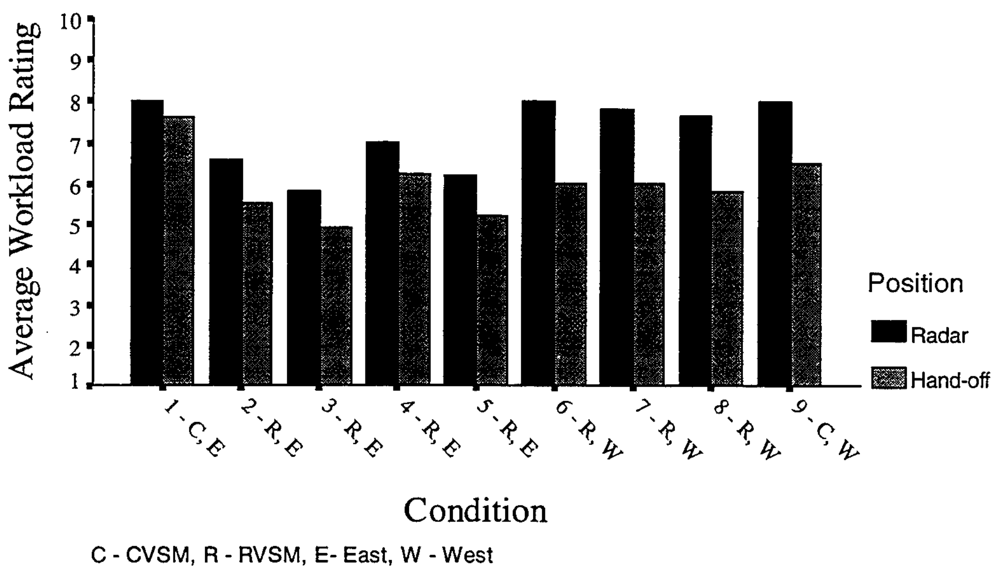

FIGURE 8. AVERAGE TECHNICAL OBSERVER-REPORTED POST-RUN CONTROLLER WORKLOAD

3.2.3.1 Workload for All Traffic Conditions

Workload ratings reported by the T/Os for all nine traffic conditions were analyzed. No statistically significant differences were found in the average workload ratings given for H controllers. However, the average workload ratings for the R controller were statistically significant, $F(8, 46) = 2.52$. Post hoc analysis, using the Tukey-HSD test, did not indicate any significant differences among all conditions. This result was not consistent with the ANOVA findings. Therefore, the less conservative Least Square Difference Test was performed. A significant difference was found between Conditions 1 and 3 and Conditions 1 and 5.

For all conditions, the T/Os reported higher average workload ratings for the R controller than for the H controller as depicted in Figure 8. While no statistical significance was found between H

controller ratings, Figure 8 clearly shows that for Condition 1, the T/Os reported higher average H controller workload than for any other condition. The overall average workload (combined average workload ratings of H and R controller) was the highest for Condition 1. The lowest average workload ratings for both control positions were observed under Conditions 3 and 5, which were split-sector eastbound traffic conditions.

3.2.3.2 Workload for Eastbound and Westbound RVSM Traffic

A statistical analysis was performed to examine whether the direction of traffic with RVSM affected controller workload. Statistical comparisons of the average workload ratings given for RVSM eastbound and westbound traffic conditions revealed that the average workload of the H controller was not significantly affected by the direction of traffic. The average workload of the R controller was significantly affected, $F(1, 46) = 13.70$, by the direction of traffic.

The average R controller workload was significantly higher for westbound traffic ($\mu = 7.83$, sd = 1.10) versus eastbound traffic ($\mu = 6.30$, sd =1.53). Although not statistically significant, the average workload rating for the H controller was also higher for westbound traffic ($\mu_{west} = 5.94$, sd = 1.98 and $\mu_{east} = 5.32$, sd = 1.72).

The overall average workload ratings (combined average workload ratings of H and R controllers) were significantly different for eastbound and westbound RVSM traffic conditions, $F(1, 44) = 5.77$. The average workload for the eastbound traffic conditions was 5.81, and the average for the westbound traffic conditions was 6.87. This indicates that the overall average workload under westbound conditions was higher than under eastbound conditions.

3.2.3.3 Workload for CVSM and RVSM with Eastbound Traffic

An analysis of the average workload for CVSM and RVSM eastbound traffic conditions revealed no significant differences in controller workload for both the H and R positions. Although not statistically different, Figure 8 displays a decrease in average controller workload for both control positions under eastbound RVSM traffic.

3.2.3.4 Workload for CVSM and RVSM with Westbound Traffic

Comparisons between westbound CVSM and RVSM traffic conditions indicated that no significant differences in average workload ratings existed for either the H or R control positions. The T/Os reported relatively the same average workload rating for all westbound conditions, regardless of separation, as shown in Figure 8.

3.2.4 Self-Reported Workload Ratings

The following subsections present analyses of post-run controller self assessment for each control position across the four traffic relationships. The average self-reported workload ratings are depicted in Figure 9.

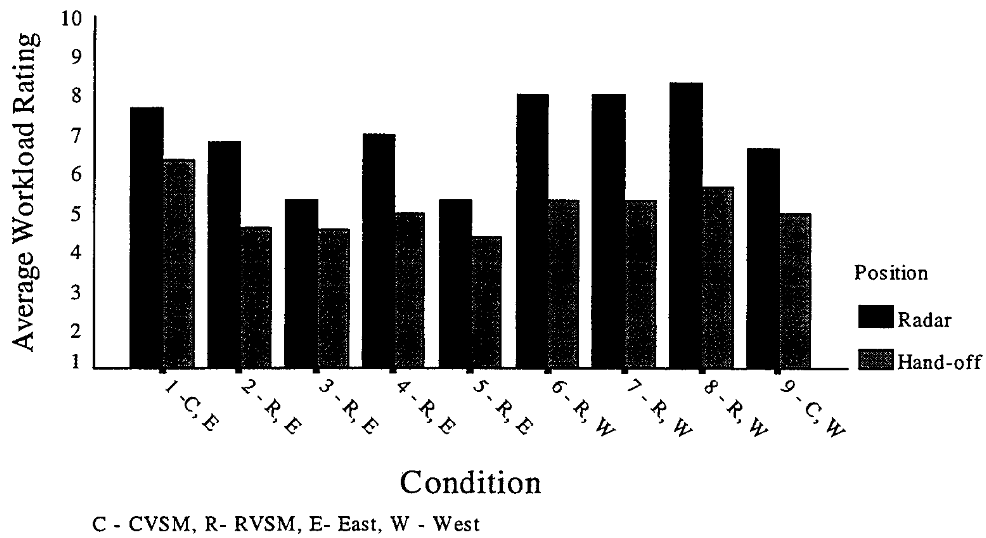

FIGURE 9. AVERAGE SELF-REPORTED POST-RUN WORKLOAD RATINGS

3.2.4.1 Workload for All Traffic Conditions

Statistical analysis indicated that the average self-reported workload ratings of the H controller were not significantly different across all traffic conditions. However, the average workload of the R controller was different across all traffic conditions, $F(8, 31) = 6.69$. Post hoc analysis showed that a difference exists between Conditions 1 and 3. Average workload for Condition 1 was 8, whereas the average workload rating for Condition 3 was 5.8. This may have been due to the fact that Condition 1 involved CVSM eastbound traffic, whereas Condition 3 involved split-sector eastbound traffic with RVSM.

For all conditions, controllers reported higher average workload ratings for the R position than for the H position, as seen in Figure 9. While no statistical significance was found between H controller ratings, Figure 9 clearly shows that, for Condition 1, controllers reported a higher average H position workload than any other condition. The lowest average workload ratings for both control positions were observed under Conditions 3 and 5, which were split-sector eastbound conditions.

3.2.4.2 Workload for Eastbound and Westbound RVSM Traffic

A statistical analysis was performed to examine whether the direction of traffic with RVSM affected controller workload. Comparisons of the average self-reported workload ratings for eastbound and westbound RVSM traffic revealed that the workload of the H controller was not significantly affected by traffic direction. However, the workload of the R controller was significantly affected, $\chi^2(1) = 12.88$, by traffic direction.

For the R controller, the average workload rating was significantly higher for westbound conditions ($\mu = 8.11$, sd = 0.60) than for eastbound conditions ($\mu = 5.76$, sd = 1.05). Although not statistically significant, the average workload rating for the H controller was also higher for westbound traffic ($\mu_{west} = 5.44$, sd = 1.50) and ($\mu_{east} = 4.58$, sd = 1.28).

The overall average workload ratings were significantly different for eastbound and westbound RVSM traffic conditions, $F(1,31) = 5.14$. The overall average workload for the eastbound traffic conditions was 5.14, and the overall average for the westbound traffic conditions was 6.77. This indicated that the overall workload under the westbound conditions was higher than the eastbound conditions.

3.2.4.3 Workload for CVSM and RVSM with Eastbound Traffic

Eastbound traffic conditions were analyzed to determine if RVSM reduced controller workload when controlling eastbound traffic. Average R controller workload was significantly different among eastbound traffic conditions, $F(4, 23) = 7.99$, but not for the H controller. Post hoc analysis indicated a difference between Conditions 1 and 3, Conditions 1 and 5, and Conditions 2 and 3.

Examination of eastbound traffic conditions in Figure 9 reveals that the highest average workload ratings for both control positions were reported under Condition 1. Lower average workload under the RVSM split sector configuration Conditions 3 and 5 as compared to RVSM combined sectors Conditions 2 and 4 are also depicted in Figure 9.

3.2.4.4 Workload for CVSM and RVSM with Westbound Traffic

Analysis of westbound traffic conditions did not reveal statistically significant differences in average workload levels for either H or R controllers. Examination of westbound traffic conditions in Figure 9 reveals that for RVSM conditions, the average reported workload was relatively the same. A slightly lower average workload for Condition 9 is also depicted in Figure 9.

3.2.5 Questionnaire Responses

Questions 5, 8, and 9 of the post-run questionnaires (Appendix B) addressed issues of task difficulty, procedural changes based on RVSM, and safety concerns. The responses conveyed by controllers and T/Os could not be measured quantitatively and therefore were not analyzed

statistically. However, the frequent appearance of these issues in questionnaires and debriefings identified them as important points regarding RVSM implementation. The frequency of responses to questions 5, 8, and 9 categorized into 5 major concerns and are depicted in Figure 10. Responses were collected from the 72 post-run questionnaires filled out after running RVSM problems (Appendix C).

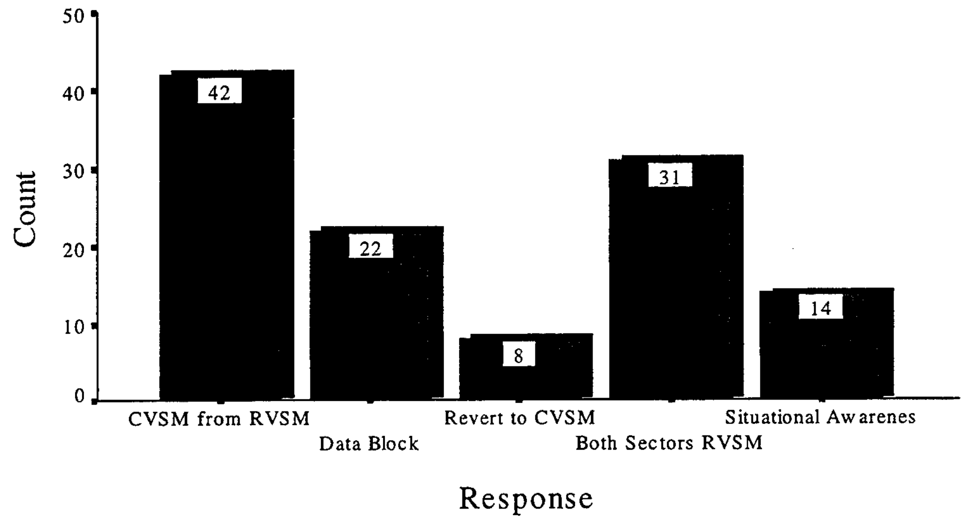

FIGURE 10. RVSM POST-RUN QUESTIONNAIRE RESPONSES

The first and most-frequently reported concern was separating RVSM-equipped and non-RVSM-equipped aircraft. Specifically, controllers were concerned with maintaining proper separation between RVSM and non-RVSM aircraft, maintaining awareness of RVSM aircraft converging with non-RVSM aircraft, and differentiating RVSM aircraft from non-RVSM aircraft. Controllers were not sure of the differences in controlling aircraft routed on tracks as opposed to random routes. Moreover, they were uncertain of how to deal with specific routes, such as A632, that are flown by non-RVSM aircraft.

The second most-frequently reported concern was allowing both sectors R65 and R86 to be RVSM transition sectors. Under all RVSM conditions, regardless of configuration type or traffic direction, it was recommended that both sectors R65 and R86 be RVSM transition sectors. The following reasons were cited for requesting RVSM in both sectors.

a. More RVSM airspace reduces the number of clearances required.

b. RVSM in R86 allows more time and space to complete tasks.

c. RVSM is needed in R86 to help set up traffic approaching R65.

The third most-frequently reported concern was difficulty maintaining data block separation during RVSM scenarios. The reduced separation created more data blocks in a closer proximity, resulting in greater overlap than during conventional separation. Controllers expressed concern that these overlaps could contribute to the loss of separation because all altitudes could not be viewed on the scope.

Reverting from RVSM to CVSM was not a frequent response on questionnaires, but it was discussed during debriefing sessions. Participants were not sure of the legal altitude assignment for RVSM-equipped aircraft prior to entering or exiting RVSM airspace.

Although not listed as a major concern on questionnaires, debriefing discussions also brought up an additional concern. Because of sometimes unreliable communications in the R65/86 area, controllers mentioned the possibility of aircraft flying into CVSM airspace at an RVSM altitude due to a temporary lack of communication. Simulated communication failure with an RVSM aircraft resulted in a separation violation in CVSM airspace.

3.3 OPERATIONAL ERRORS AND DEVIATIONS

The operational errors and deviations[11] observed and recorded by the T/Os during the simulation are listed in Table 6. The time given is the number of minutes into the simulation. All except one of the reported errors were observed during eastbound traffic conditions. At least two of the operational errors reported during the simulation involved RVSM and non-RVSM aircraft. The most errors, three, were observed under NE06.

A test of proportions using Binomial distribution was performed to compare the proportion of errors observed under multi-transition sectors (R65 and R86) and single transition sector (R65) configurations. These proportions were not statistically different.

4. DISCUSSION

When this study was being conducted, New York ARTCC sectors R65 and R86 experienced two distinct traffic pushes. One push had a majority of eastbound traffic, while the other was primarily westbound. To accommodate these traffic patterns, this study was conducted to analyze the effects of RVSM for both traffic flows, including workload and operational errors. These two discrete traffic patterns were confirmed by the fact that higher overall (R and H combined) average workload levels were observed during the westbound traffic flows compared to the eastbound traffic. Consequently, the following paragraphs address eastbound and westbound traffic individually. The study was also aimed at determining whether RVSM should be employed exclusively in sector R65 or in both sectors R65 and R86.

Compared to CVSM, RVSM did not increase R or H controllers' workload under eastbound traffic conditions. In all eastbound conditions, the observed workload was lower under RVSM than CVSM and, in some cases, these differences were statistically significant. The lowest workload levels were experienced when RVSM was coupled with a split-sector configuration. Stein (1985) found that duration of ground-to-air communications, controller keyboard entries, number of altitude changes, and aircraft density (per volume of airspace) were significantly related to workload. Controllers explained that the use of RVSM for eastbound traffic resulted in

[11] Refer to 7210.3K, *Facility Operation and Administration*, section 5-1 for definitions of operational errors and deviations.

TABLE 6. OPERATIONAL ERRORS AND DEVIATIONS NOTED BY THE TECHNICAL OBSERVERS

Date	Scenario	Sector	Time :min.:sec	Type of Operational Error/Deviation
09-07-94	NE04	R65/R86	:28:00	[a] Loss of separation between IBE956 and ACA954.
09-07-94	NE05	R65/R86	:08:00	Loss of separation between AZA601 and TWA900, 90° heading.
			:22:00	USA842 W51 airspace without a hand off.
09-07-94	NE06	R65/R86	:44:29	Loss of separation between TWA904 and UAL156 (speed overtake).
			:50:00	[a] BWA601 was a non-RVSM aircraft operating at FL 370. TWA904 was at FL 360. Separation violation over SLATN.
			49:00	USA454 penetrated Sie Ilse (W59) airspace at FL 230 without point out.
09-08-95	SWBASE	R65/R86	:30:00	M515 FL 290 penetrated W59 and B31 airspace. Aircraft should have been out of FL 180 or lower because of crossing restrictions.
09-09-94	Actual	R65/R86	:16:00	Loss of separation between AAL34 and USA177. Both approved over JOBOC at the same time and altitude (FL 390).
			:11:00	UAL910 penetrated D87 airspace proceeding direct SLATN at FL 370.
09-12-94	NE04	R65/R86	:59:00	Loss of separation between RAM205 and AAL121 resulting from crossing situation. RAM205 climbing to FL 290 when AAC121 was at FL 280. Controllers' attention diverted with traffic in sector 86.
09-13-95	NE01	R86	:40:00	APW556 and COA580: sector 86 was supposed to give sector 66 20 miles in trail. Aircraft were 9 miles in trail with second aircraft 20 knots faster.
09-13-94	NE02	R86	:02:00	Loss of separation between VIR010 and AAL842. At FL 140, AAL842 and VIR010 put on converging courses, not in trail.
09-13-94	NE03	R86	:48:00	[a] DAL42 was operating at FL 360. ACA969 was a non-RVSM aircraft operating at FL 350 (separation 6.5 miles). Controller forgot ACA969 was not RVSM equipped.
09-14-94	NE01	R86	:21:12	APW556 deviated into W107 without prior coordination.

[a] Error resulting from RVSM separation.

less vectoring and reduced communications between the radar and oceanic controllers. This may have decreased controller workload for eastbound RVSM traffic.

Compared to CVSM, a decrease in workload was not observed while utilizing RVSM under westbound traffic conditions. In some cases, an increased workload was observed. Controllers reported that maintaining in-trail separation required more vectoring under RVSM compared to CVSM. This may have resulted in more communications, leading to an increased workload. Controllers also explained that most of the aircraft heading westbound inevitably required landing clearances (i.e., altitude changes). Both vectoring and giving commands in preparation for landing clearances require controllers to communicate with pilots and make keyboard entries, which may have increased the workload for the westbound RVSM traffic. However, some controllers suggested that early planning for in-trail spacing would alleviate this problem. This implies a need for training controllers to execute timely in-trail separation planning under RVSM.

It was assumed that some operational errors would occur due to the lack of experience that controllers had with reduced separation. Results showed that most operational errors occurred during the eastbound RVSM traffic conditions. This may be because, unlike westbound traffic, eastbound RVSM traffic conditions required increased awareness to maintain separation between mixed aircraft (i.e., RVSM and non-RVSM equipped). However, controllers expressed that increased experience with RVSM separation would alleviate these errors. This experience can be provided to controllers via training. Furthermore, requiring all transiting aircraft to be RVSM-equipped would help eliminate these errors.

Irrespective of aircraft equipage (i.e., RVSM or non-RVSM), westbound traffic normally demands that controllers issue commands, including vectoring, in preparation for a landing clearance. Controllers reported increased vectoring under RVSM compared to CVSM for westbound traffic. Although RVSM increased vectoring for westbound traffic, controllers were accustomed to this operation. Therefore, no operational errors were observed, despite the increase in controller workload. This implies that RVSM did not affect controller performance during westbound traffic.

Operational errors were observed under both RVSM transition airspace configurations: only sector R65 and both sectors R65 and R86. Average workload ratings were relatively constant regardless of which transition airspace was utilized. Although operational errors and average workload showed no difference between sector R65 and sectors R65 and R86 as transition airspace, the controllers preferred the latter. The additional transition airspace provided controllers with increased flexibility to complete control tasks.

Simulation results indicated that it is feasible to use domestic oceanic sectors R65 and R86 for RVSM transitions. Under some conditions, RVSM helped reduce workload. However, for the conditions that RVSM did not reduce workload, controller performance was not affected. Training is recommended to address mix of aircraft and in-trail separation planning issues under RVSM. Before RVSM can be safely implemented in this airspace, guidelines to handle potential complications, such as communication failure, also need to be developed by the New York ARTCC.

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APPENDIX A
BACKGROUND INFORMATION

TABLE A1. CONTROLLER AND OBSERVER BACKGROUND INFORMATION SUMMARY

	Controllers:					Observers:			Ctrls:
	A	B	C	D	W	Y1	X	Y	Mean
Ages	42	34	38	35	25	30	35	32	37.25
Years FPL	8.33	1.66	7.83	1.83	N/A	7.00	7.25	12.00	4.91
Years Oceanic	8.33	1.66	7.83	4.50	N/A	3.00	7.25	6.00	5.58
Years as NAT FPL Oceanic Controller	8.33	1.66	7.83	4.50	N/A	3.00	7.25	6.00	5.58
Months Since Controlling Oceanic	0	0	0	0	N/A	0	0	0	0
Years as a Trainer in ATC	8.16	3.58	10.50	4.00	N/A	4.00	6.25	0	6.56
Facilities Worked	NY ARTCC	NY ARTCC	NY ARTCC	NY ARTCC	NY ARTCC	NY ARTCC	NY ARTCC	ZBW OTIS TWR	

Q1. If you had an opportunity to change three current elements in the oceanic radar area (practices, procedures, equipment, etc.), what would they be?

A	Better frequency coverage, complete sector radar coverage.
B	Adequate frequency coverage.
C	Equipment - controller assurance of safety could be enhanced with a frequency override feature. Procedures - use of visual separation with pilot concurrence would facilitate traffic flow. Standardization of procedures for international traffic would eliminate confusion among pilots. Equipment - high speed printers. Procedures - reduce number of flight strips.
D	Equipment - better communications/frequencies procedures on use of warning areas.
W	Most of the FAA's radar system equipment is antiquated. There is a need for a clearer visual display with greater radar coverage and more accurate weather information.
Y1	Better radar coverage. Better frequency coverage. Better weather display ability.
X	The experience level of the R controller is very young. The radar in the oceanic area needs more experienced controllers.
Y	Radar coverage, automation, GPS.

Q2. Based on your experience with high traffic and high workload in oceanic radar operations:

a) What are some of the things that can occur that cause you to have significant difficulties in maintaining an orderly and expeditious traffic flow?

A	Loss of sector awareness, overwhelmed by phone calls and ARINC messages.
B	1) Frequency congestion and, with two frequencies with R86/65 combined aircraft stepping on each other or, with one frequency or speaker competing with background noise in the area; 2) Having to handle weather deviations, especially coordinating with the appropriate D sector that's involved.
C	1) Severe weather; 2) Frequency congestion; 3) Unexpected occurrences, i.e., emergencies; and. 4) Volume.
D	1) Bad frequency coverage at lower flight levels and at edge of frequency coverage; 2) Flights do not hear ATC - say we were "stepped on" which leads to repeating clearances.
W	Equipment outages (radar outages, aircraft instrument failure, etc.), adverse weather; and emergencies.
Y1	1) Inability to communicate with other aircraft while a flight is reading back long clearances, such as oceanic clearances; 2) working two frequencies at the same time.
X	1) Weather; 2) In-trail restrictions; 3) Unexpected holding (adjacent facilities refusing traffic); and 4) Emergencies.
Y	1) Radio coverage; 2) congestion; 3) speech difficulties (foreign dialects); 4) Aircraft performance.

b) Which of these events tend to occur most frequently?

A	Excessive phone calls.
B	Depends on the season - weather deviations are more prevalent in the summer.
C	Volume.
D	Both occur very frequently.
W	Adverse weather.
Y1	Both.
X	Weather and in-trail restrictions.
Y	Speaker and radio congestion.

c) Which of these events tend to most likely cause additional problems?

A	Falling behind on ARINC messages.
B	Weather deviations - pilot requests will add to frequency congestion as well as coordination workload (with adjacent D sectors).
C	Weather.
D	Both cause additional problems.
W	Adverse weather creates many problems for the non-radar oceanic sectors that R86/65 coordinates with - such problems are usable altitudes and in-trail spacing. Longitudinal spacing is hindered by weather deviations.
Y1	Communication.
X	Weather.
Y	Both.

Q3. Please check all items below that you feel contribute significantly to high levels of workload in the current oceanic radar ATC system:

	A	B	C	D	W	Y1	X	Y	Response Frequency
Printer Speed ODAPS	X		X	X	X	X			5
Printer Speed Host									0
Active Warning Areas		X			X				2
Oceanic Clearances		X	X	X	X	X	X	X	7
Phone System									0
Special Pilot Requests		X			X				2
Sector Splits	X		X		X				3
Coordination with Fellow Controllers	X	X	X			X		X	5
Oceanic Track System					X				1
Random Routes	X		X		X				3
Aircraft Performance Characteristics/Mix			X		X	X		X	4
Other		X					X		2

Q3. Additional Comments:

A	The ODAPS printer backs up since its workload can only be divided by splitting the "O" sectors, which is not commonly done. Lack of sector splits can overburden a controller. Random routes sometimes window more than standard coordination.
B	Other: Lack of flow control.
C	ODAPS does not print strips fast enough to provide flight information to manual sectors. Coordination with D controllers is often delayed because D controllers are often busy with higher priority duties.
D	ODAPS many times does not have eastbound flight plans in its system. Oceanic clearances are time consuming; room for error with foreign speaking pilots.
W	I feel the oceanic track system and sector splits minimize workloads. The following contribute to high levels of workload: ODAPS strip generation; relaying numerous oceanic clearances (especially those to foreign air carriers where communication is sometimes difficult); slow climbing aircraft; aircraft on random routes or those requesting direct routings; active warning areas; and extensive military activity.
Y1	Taking time to generate strips for non-radar, in-house coordination is very long, clearances are lengthy, and if read back incorrectly, it has to be redone.
X	Other: Weather, holding, in-trail restrictions.
Y	(No comment)

APPENDIX B
CONTROLLER AND OBSERVER FORMS

CONTROLLER/OBSERVER FORM I INSTRUCTIONS

1. This form is to be completed by all controllers and observers prior to participation in the NSC RVSM Phase II simulation activities. The form consists of requests for general background information and an initial (baseline) judgment regarding oceanic radar control practices.

2. Participants should be advised that their names will not be listed or appear in any of the NSC data records to ensure anonymity and to encourage unbiased reporting. Findings will be reported as group data and generically as Controller A, B, C, etc.

CONTROLLER/OBSERVER FORM I

DATE:_______________ AGE:______

CONTROLLER: A B C D W OBSERVER: X Y

1. Indicate the total time you have worked as a full performance level controller (in any control position, not only oceanic):

   YEARS________ MONTHS_________

2. Please indicate the total time you have worked as a full performance level *oceanic radar* controller (only oceanic experience):

   YEARS________ MONTHS_________

3. Please indicate the total time you have worked as a full performance level oceanic radar controller with North Atlantic traffic (as opposed to Pacific traffic):

   YEARS________ MONTHS_________

4. Please indicate how long it has been *since* you last controlled oceanic radar traffic (i.e., indicate 0 if currently active):

   YEARS________ MONTHS_________

5. Please indicate the total experience you have as a trainer of controllers (for any control position):

   YEARS________ MONTHS_________

6. Starting with your current facility, please list all FAA facilities that you have worked in throughout your career as a controller:

   (1)_______________ (2)_______________ (3)_______________ (4)_______________

CONTROLLER/OBSERVER FORM I (cont.)

GENERAL PROCEDURES & PRACTICES INFORMATION
7. If you had an opportunity to change three current elements in the oceanic radar area (practices, procedures, equipment, etc.), what would they be?
8. Based on your experience with high traffic and high workload in oceanic radar operations: a) What are some of the things that can occur that could cause you to have significant difficulties in maintaining an orderly and expeditious traffic flow ?
b) Which of these events tend to occur most frequently?
c) Which of these events tend to most likely cause additional problems?
9. Please check all items below that you feel contribute significantly to high levels of workload in the current oceanic radar ATC system:

- ❒ Printer Speed ODAPS__ Host__
- ❒ Active Warning Areas
- ❒ Oceanic Clearances
- ❒ Phone System
- ❒ Special Pilot Requests
- ❒ Other ______________________
- ❒ Sector Splits
- ❒ Coordination with Fellow Controllers
- ❒ Oceanic Track System
- ❒ Random Routes
- ❒ Aircraft Performance Characteristics/Mix
- ❒ Other ______________________

Please include comments (explanations) on any of the above checked items:

1. This form is to be completed by all controllers after each completed simulation run in the NSC RVSM Phase II simulation activities. The form consists of requests for information regarding overall experiences and judgments about the simulation run just completed.

2. The RATING NUMBERS to be used for item #4 are:

   1 = Remarkably good
   2 = Moderately good
   3 = So-so
   4 = Not very good
   5 = Unusually poor

CONTROLLER FORM II/POST SIMULATION RUN QUESTIONNAIRE

DATE: SCENARIO:

CONTROLLER: A B C D

CONTROL POSITION: R H

1. Please estimate your overall WORKLOAD during the last simulation (circle one).

1	2	3	4	5	6	7	8	9	10
VERY LOW				MODERATE					VERY HIGH

2. In terms of REALISM, rate the PHYSICAL SIMULATION ENVIRONMENT (circle one).

1	2	3	4	5	6	7	8	9	10
VERY LOW				MODERATE					VERY HIGH

3. In terms of FUNCTIONAL REALISM, rate the SIMULATED TRAFFIC (circle one).

1	2	3	4	5	6	7	8	9	10
VERY LOW				MODERATE					VERY HIGH

4. Please judge your OWN PERFORMANCE over the most recent simulation run. Using the RATING NUMBERS from the instruction sheet for each position worked, insert the appropriate rating into each box next to the following factors:

HAND-OFF POSITION	RADAR-POSITION
☐ Proper Coordination	☐ Proper Coordination
☐ Promptness of Actions	☐ Promptness of Actions
☐ Situation Awareness Maintenance	☐ Situation Awareness Maintenance
☐ Communication Management	☐ Communication Management
☐ Proper Message Construction	☐ Proper Clearances Issued
☐ Computer Entry Management	☐ Flight Strip Management
☐ Other____________________	☐ Maintenance of Separation

CONTROLLER FORM II (cont.)
CVSM (BASELINE)

5. What was most difficult for you to accomplish during the simulation?

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures, etc.) , what would it be?

7. Did you change your usual control and work strategies in any way in order to work the traffic in the last simulation? If so, how? What did you do differently?

8. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

CONTROLLER FORM II (cont.)
RVSM CONDITIONS

5. What was most difficult for you to accomplish during the simulation?

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures, etc.), what would it be?

7. Did you change your usual control and work strategies in any way in order to work the traffic with RVSM? If so, how? What did you do differently?

8. Based upon your experience with RVSM in the last simulation run, what procedures (equipment) would have to be changed and/or implemented in order for you to continue to be comfortable about transitioning this traffic?

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

RVSM PHASE II
TECHNICAL OBSERVER "QUICK" FORM INSTRUCTIONS

1. This form is to be completed by trained technical observers during each simulation run.
2. Observations and responses will be recorded in 15-minute intervals. A new (identical) form should be used for each 15-minute time period.
3. Observations will be made on this form primarily for the Radar-Position controller. However, both controllers (Radar and Hand-off) will be prompted for their workload rating at 15-minute intervals and the observer will make "quick evaluations" about performance on both positions.
4. The rating numbers for <u>WORKLOAD</u> are on a scale from 1 to 10 with:

   1 = very low workload
   5 = moderate workload
   10 = very high workload

5. The rating numbers for the rest of the QUICK EVALUATIONS are:

   1 = Remarkably good
   2 = Moderately good
   3 = So-so
   4 = Not very good
   5 = Unusually poor

TECHNICAL OBSERVER "QUICK" FORM

TIME:_____:_____:_____ DATE: SCENARIO:

SECTOR: R65 R86 R65/R86 OBSERVER: X Y

OBSERVER EVALUATIONS (circle one)

WORKLOAD

"R"	1	2	3	4	5	6	7	8	9	10
"H"	1	2	3	4	5	6	7	8	9	10

COORDINATION AND COMMUNICATION

"R"	1	2	3	4	5	6	7	8	9	10
"H"	1	2	3	4	5	6	7	8	9	10

TRAFFIC MANAGEMENT

"R"	1	2	3	4	5	6	7	8	9	10
"H"	1	2	3	4	5	6	7	8	9	10

FLIGHT STRIP MANAGEMENT

"R"	1	2	3	4	5	6	7	8	9	10
"H"	1	2	3	4	5	6	7	8	9	10

CONTROLLER RATING (circle one)

WORKLOAD

"R"	1	2	3	4	5	6	7	8	9	10
"H"	1	2	3	4	5	6	7	8	9	10

RESTRICTIONS ISSUED (hash marks):

SPEED
TIME
ALTITUDE
ROUTING
VECTORS

NON-RADAR COORDINATION (hash marks):

PILOT
ADJACENT SECTOR/FACILITY

TECHNICAL OBSERVER "QUICK" FORM (cont.)

OPERATIONAL ERROR(s) OBSERVED:

TIME:_____:_______:_____

☐ Loss of Separation
☐ Other_____________________

Briefly describe what happened:

____

____

OPERATIONAL ERROR(s) OBSERVED:

TIME:_____:_______:_____

☐ Loss of Separation
☐ Other_____________________

Briefly describe what happened:

____

____

OPERATIONAL ERROR(s) OBSERVED:

TIME:_____:_______:_____

☐ Loss of Separation
☐ Other_____________________

Briefly describe what happened:

____

____

OPERATIONAL ERROR(s) OBSERVED:

TIME:_____:_______:_____

☐ Loss of Separation
☐ Other_____________________

Briefly describe what happened:

____

____

RVSM PHASE II
OBSERVER FORM II INSTRUCTIONS

1. This form is to be completed by all observers after each completed simulation run in the NSC RVSM Phase II simulation activities. The form consists of requests for information regarding overall experiences and judgments about the just-completed simulation run.

2. The RATING NUMBERS to be used for item #4 are:

   1 = Remarkably good
   2 = Moderately good
   3 = So-so
   4 = Not very good
   5 = Unusually poor

RVSM PHASE II

OBSERVER FORM II/POST SIMULATION RUN QUESTIONNAIRE

DATE: SCENARIO:
OBSERVER: X Y
SECTOR OBSERVED: R65 R86 R65/86

1a. Estimate the overall Radar position WORKLOAD during the last simulation (circle one):

CONTROLLER: A B C D

1	2	3	4	5	6	7	8	9	10
VERY LOW				MODERATE					VERY HIGH

1b. For each controller please estimate the overall Hand-off position WORKLOAD during the last simulation (circle one):

CONTROLLER: A B C D

1	2	3	4	5	6	7	8	9	10
VERY LOW				MODERATE					VERY HIGH

2. In your opinion, in terms of REALISM, how real was the PHYSICAL SIMULATION ENVIRONMENT for the controllers (circle one)?

1	2	3	4	5	6	7	8	9	10
VERY LOW				MODERATE					VERY HIGH

3. In your opinion, in terms of FUNCTIONAL REALISM, how real was the SIMULATED TRAFFIC for the controllers (circle one)?

1	2	3	4	5	6	7	8	9	10
VERY LOW				MODERATE					VERY HIGH

OBSERVER FORM II/POST SIMULATION RUN QUESTIONNAIRE (cont.)

4. Please judge OVERALL CONTROLLER PERFORMANCE during the most recent simulation run. Using the RATING NUMBERS from the instruction sheet, insert the appropriate rating number for each of the positions observed into the box next to each of the following factors:

HAND-OFF POSITION CONTROLLER: A B C D	RADAR POSITION CONTROLLER: A B C D
☐ Proper Coordination	☐ Proper Coordination
☐ Promptness of Actions	☐ Promptness of Actions
☐ Situation Awareness Maintenance	☐ Situation Awareness Maintenance
☐ Communication Management	☐ Communication Management
☐ Proper Message Construction	☐ Proper Clearances Issued
☐ Computer Entry Management	☐ Flight Strip Management
☐ Other____________________	☐ Maintenance of Separation

5. What was most difficult for controllers to accomplish during this simulation?

(at the) Hand-off Position	(at the) Radar Position

OBSERVER FORM II/POST SIMULATION RUN QUESTIONNAIRE (cont.)
CVSM (Baseline)

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures, etc.), what would it be?

7. Did the controllers change their usual control and work strategies in any way in order to work the traffic in the last simulation? If so, how? What did they do differently?

8. Based upon your observations of the traffic load during the last simulation run, what procedures (equipment) would have to be changed and/or implemented in order for the controllers to be comfortable about working this same traffic but under RVSM?

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures, etc.), what would it be?

7. Did the controllers change their usual control and work strategies in any way in order to work the traffic with RVSM? If so, how? What did they do differently?

8. Based upon your observations with RVSM in the last simulation run, what procedures (equipment) would have to be changed and/or implemented in order for the controllers to continue to be comfortable about working this traffic?

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

APPENDIX C
SUMMARY OF POST-SIMULATION RESPONSES

5. What was most difficult for you (the controllers) at the: 1) Hand-off Position "H", 2) Radar Position "R") to accomplish during the simulation?

Q5. NE01		
Run 1	A	"H" (No comment)
	B	"R" Get altitude approvals.
	C	"H" Data block separation.
	D	"R" Data block separation. Getting used to inputs (a little different.)
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" No problems. RVSM made it a lot easier. "R" RVSM problem was run pretty smooth. No major problems.
Run 2	C	"H" Judging times at exit fixes - JOBOC and SLATIN.
	A	"R" (No comment)
	D	"H" No difficulties.
	B	"R" Nothing was especially difficult.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" Easy Problem. "R" Easy problem.
Run 3	B	"H" Nothing.
	A	"R" 40 MIT to be Robinsville (RBV).
	D	"H" Coordinating altitudes when RVSM was canceled; particularly, quickly coming up with good altitudes.
	C	"R" Reverting to CVSM from RVSM.
	(X)	"H" Maintaining data block separation. "R" No difficulties noted.
	(Y)	"H" To revert to CVSM from RVSM. "R" To revert to CVSM.

Q5. NE02		
Run 1	B	"H" Remain traffic aware while performing "H" duties. Requesting needed strips and coordinating with adjacent sectors.
	A	"R" Getting the airplanes to comply with their clearances.
	D	"H" Many aircraft rerouted onto tracks. No routes entered in computer as no time.
	C	"R" Issue oceanic clearances and assign requested altitudes in timely manner.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" Busy problem, RVSM helped this problem at SLATN primarily. "R" Frequency congestion was the most difficult to handle.
Run 2	A	"H" Keeping the "R" man off my strips.
	B	"R" Nothing.
	C	"H" No difficulties.
	D	"R" Get aircraft to talk to me. The pilot fell behind a little.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" Very Easy. "R" Very Easy.
Run 3	C	"H" No difficulties.
	A	"R" MIT to be Robinsville
	D	"H" Separating the data blocks.
	B	"R" Nothing.
	(X)	"H" No real difficulties. "R" No real difficulties.
	(Y)	"H" RVSM suspended at 23:10:15; work finished at 23:13:40. Another RVSM to CVSM problem. Being able to utilize RVSM 330 (Down), 370 (Up) made the transition easier, also the canceled RVSM occurred a little early in the problem. "R" (No comment)

Q5. NE03		
Run 1	A	"H" Absolutely nothing.
	B	"R" Nothing.
	C	"H" No difficulties.
	D	"R" Pilots not taking clearances or missing clearances.
	(X)	"H" No difficulties noted. "R" Maintaining awareness of RVSM and non-RVSM aircraft. DAL42 had climbed to FL 360 with ACA959 at FL 350.
	(Y)	"H" No difficulties; easy problem. "R" Moderate traffic for 10 minutes; controller handled the traffic easily.
Run 2	B	"H" Nothing.
	A	"R" Nothing.
	D	"H" No difficulties.
	C	"R" Issuing oceanic clearances in a timely manner.
	(X)	"H" No difficulties noted. "R" Remembering to use CVSM separation between RVSM and non-RVSM aircraft.
	(Y)	"H" No real problems. "R" No real problems.
Run 3	B	"H" For a short time, data block overlap and slow climb rates complicated the traffic picture somewhat.
	A	"R" Nothing.
	D	"H" No difficulties.
	C	"R" No difficulties.
	(X)	"H" No difficulties noted. "R" controller had difficulty maintaining separation. Many headings and directs created conflicts.

Q5. NE04		
Run 1	A	"H" Coordination with D72 and other facilities was very difficult to accomplish.
	B	"R" Find the appropriate flight strip (especially for the approved altitudes eastbound). Identify flights due to data block overlap.
	(Y)	"H" Clear communications with others. "R" Work heavy traffic with technical distractions and communication problems.
Run 2	B	"H" Get altitude approvals from D72. This impacted the "R" controller somewhat. This was more realistic.
	C	"R" Remembering to keep RVSM from non-RVSM aircraft.
	(X)	"H" Data block management. "H" controller really did not help "R" controller. "R" Working with "H" controller. "H" controller really did not help.
	(Y)	"H" (No comment) "R" (No comment)
Run 3	C	"H" Computer entries (fumble fingers).
	A	"R" Cross non-RVSM and RVSM aircraft.
	(X)	"H" No difficulties noted. "R" Due to the number of aircraft, controllers' attention was diverted with traffic in sector 86. They were not aware of situation developing in sector 65.
	(Y)	"H" Maintain situation awareness. Aircraft load was handled well. A heavy load of aircraft keeps the H controller more involved in the strips. "R" (No comment)

Q5. NE05		
Run 1	B	"H" Keeping data blocks from overlapping and coordinating with adjacent sectors made it hard to keep up with the traffic picture.
	C	"R" Maintain safe orderly flow.
	(X)	"H" Coordination with R controller. Maintaining management of sector data blocks. "R" Sector management of data blocks. Management of aircraft.
Run 2	A	"H" (No comment)
	B	"R" Work the Northbound R86 traffic (including vectoring for spacing) while having to give several oceanic clearances.
	(X)	"H" Communicating with the R controller. "R" It appears R controller was not paying attention to read backs of oceanic clearances because he was watching other situations.
	(Y)	"H" No difficulties. "R" (No comment)
Run 3	C	"H" No real difficulties.
	A	"R" It was easy.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" Simulation was moderate; not of major difficulty. "R" (No comment)

Q5. NE06		
Run 1	C	"H" No difficulties, except remembering to keep RVSM from non-RVSM aircraft by CVSM or longitudinal separation.
	A	"R" Separate CVSM from RVSM aircraft legally for D72. (I wasn't aware I needed to.)
	(X)	"H" Seemed to be no difficulties. "H" person had situation in control. "R" Separation of non-RVSM (MNPS) aircraft with RVSM (MNPS) aircraft.
	(Y)	"H" (No comment) "R" (No comment)
Run 2	A	"H" (No comment)
	B	"R" No special difficulties.
	(X)	"H" No real difficulties. In fact, prompted the "R" man several times with control decisions. "R" Controller got tunnel vision concentrating on R65 traffic and neglecting situations on R86. The "R" man was not concentrating on read backs.
	(Y)	"H" Not a difficult problem. "R" (No comment)
Run 3	B	"H" Keep data blocks from overlapping.
	C	"R" Keep RVSM from CVSM aircraft.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" (No comment) "R" Situation awareness dropped some. The controller was a little tired.

Q5. Actual		
Run 1	A	"H" Coordination was increased because less altitudes.
	B	"R" Set up in-trail situations. Had to vector several aircraft for spacing.
	(X)	"H" Coordination with "R" man sometimes hard to get to. "R" Frequency management and traffic flow had many in-trail situations that resulted in ineffective traffic flow due to excessive vectoring.
	(Y)	"H" Make altitudes available for traffic. "R" (No comment)
Run 2	B	"H" Get the proper strips posted and get altitude approvals from D72.
	C	"R" Correlating strip times at JOBOC and SLATIN with actual times over the fix. Large discrepancies (more than 3 minutes) may affect separation.
	(X)	"H" Maintaining separation going into non-radar environment. "R" controller was terminating radar early and did not maintain awareness of converging traffic, resulting in loss of separation.
	(Y)	"H" (No comment) "R" (No comment)
Run 3	C	"H" Providing accurate times over JOBOC and SLATN for manual controller in order for him to assign altitudes.
	A	"R" It was a mess. Separating data blocks.
	(Y)	"H" Accommodate aircraft and altitudes at JOBOC and SLATN. "R" Coordinate with H position and accomplish altitude assignments.

Q5. SW BASE		
Run 1	C	"H" Maintain clear picture of traffic situations and effect proper coordination with other sectors/facilities.
	A	"R" Keeping the data blocks from overlapping.
	(X)	"H" No real difficulties. "R" No real difficulties.
	(Y)	"H" Keep plane separated. "R" (No comment)
Run 2	B	"H" Nothing.
	C	"R" No difficulties.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" (No comment) "R" CVSM.
Run 3	A	"H" Figure out what "R" was doing.
	B	"R" AAL567 made a deviation request (southbound just N of CHAMP) taking up a lot of time when workload was peaking with a mix of N (down) and S (up) in the corridor between W107 and W105.
	(Y)	"H" Not a lot of difficulty for the assistant. "R" Work load was high, controller got behind throughout most of problem. Frequency congestion was higher due to coordination.

Q5. SW RVSM		
Run 1	C	"H" Keep data blocks separated.
	A	"R" Keep data blocks apart.
	(X)	"H" Separation of data blocks. Scope management was difficult because of the amount of aircraft converging at LINND. "R" Frequency congestion was a problem due to the high volume of traffic.
	(Y)	"H" The problem very busy. Both controllers did a very good job, especially the radar traffic flow westbound and Champ S-E bound. "R" (No comment)
Run 2	A	"H" Getting the strips that were destroyed.
	B	"R" Working two separate and distinct flows. Southbound in R86 climbing US and Westbound descending impacting each other.
	(X)	"H" Determining what the "R" controller plan was to maintain in-trail spacing. "R" In-trail separation. "R" controller waited too long to determine the in-trail flow to JFK. This created a lot of extra work.
	(Y)	"H" Helping the R controller in traffic management. "R" (No comment)
Run 3	B	"H" Keep up with the traffic picture while performing "H" duties.
	C	"R" Keeping traffic picture.
	(Y)	"H" Not a problem that created an extra large work load for this position. "R" Very heavy SW bound push. Controller did a very good job. This exercise was primarily a radar problem; there wasn't a lot the H controller could do to help the controller.

Q5. SW KENDA		
Run 1	A	"H" Keep track of strip marking.
	B	"R" Sequence the two flows merging at KENDA. There was a lot of vectoring for spacing and speed control.
	(X)	"H" No real difficulty. "R" Maintaining in-trail operation. "R" controller issued many vectors to maintain separation. These vectors compounded the problems and required more vectors.
	(Y)	"H" Keep the R controller alert to aircraft straying off course. "R" (No Comment)
Run 2	B	"H" With both sectors combined, I was on the line with adjacent sectors so much. It was hard to remain aware of what the "R" controller was doing.
	C	"R" Keeping traffic picture.
	(X)	"H" Difficulties maintaining data block separation. "R" The difficult thing for the "R" controller was to determine which aircraft had to descend and which were over flights.
	(Y)	"H" Coordinate H positions at CHAMP. The heavy traffic load at CHAMP created some difficulty for the H controller. "R" (No comment)
Run 3	A	"H" No difficulties.
	A	"R" Sequencing the many flights to JFK.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" (No comment) "R" In-trail spacing to JFK. RVSM in 65/86 helped keep this busy problem manageable.

Q5. SW MTT		
Run 1	C	"H" Keep data blocks separated for "R" controller.
	A	"R" Data block overlap.
	(X)	"H" No real difficulties. "R" No real difficulties. Problem ran smoothly.
	(Y)	"H" Very busy problem. Both controllers did an excellent job and work well with each other. RVSM made this problem more workable. "R" (No comment)
Run 2	B	"H" Remain aware of the traffic situation because of time consuming coordination with D87.
	C	"R" Sequencing aircraft from JOBOC and SLATIN via CAMRN.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" Maintain situational awareness when problem is very busy and do strips. "R" (No comment)
Run 3	A	"H" Nothing.
	B	"R" Get a word in edge wise to issue clearances with aircraft checking on and/or making request - frequency - congestion.
	(X)	"H" No difficulties noted. "R" No difficulties noted.
	(Y)	"H" (No comment) "R" Just busy traffic, in-trail spacing and separation.

6. If you could change something about the last simulation run (anything at all about the traffic scenario, aircraft, procedures, etc.), what would it be?

Q6. NE01		
Run 1	A	"H" (No comment)
	B	"R" Nothing.
	C	"H" Aircraft routed through active warning areas should be routed around warning areas.
	D	"R" Need strips on time.
	(X)	Nothing, good scenario.
	(Y)	Maybe one more aircraft proceeding westbound at beginning of problem.
Run 2	C	"H" No changes.
	A	"R" (No comment)
	D	"H" Many strips on flights going to SLATIN/JOBOC did not print out and had to be strip requested.
	B	"R" Nothing except have RVSM in R86.
	(X)	No change, simulation seems realistic.
	(Y)	4 to 5 more aircraft.
Run 3	B	"H" Get all the necessary strips. We're missing a lot of the strips for flights that transition to R65.
	A	"R" They would turn and take headings when issued.
	D	"H" None.
	C	"R" Simulate traffic on A699 and A700 to block out altitudes.
	(X)	No change.
	(Y)	One more aircraft over JOBOC during RVSM to CVSM change.

Q6. NE02		
Run 1	B	"H" Nothing.
	A	"R" Get the speeds fixed.
	D	"H" No change.
	C	"R" No changes.
	(X)	Change nothing. Scenario realistic.
	(Y)	Wouldn't change anything.
Run 2	A	"H" Check those speeds.
	B	"R" Nothing.
	C	"H" No changes.
	D	"R" A few aircraft came out at same time/same altitude.
	(X)	No changes. Simulation realistic.
	(Y)	5 to 6 more aircraft.
Run 3	C	"H" No changes.
	A	"R" No.
	D	"H" None.
	B	"R" Airspeeds are still occasionally unrealistic and/or fluctuate.
	(X)	No change.
	(Y)	Have more aircraft requesting RVSM altitudes. Have the problem a little busier before RVSM was canceled.

Q6. NE03		
Run 1	A	"H"
	B	"R" Nothing.
	C	"H" Deny use of warning areas (W105 and W107)
	D	"R" None.
	(X)	Nothing. Scenario was realistic.
	(Y)	Add four more aircraft, 2 eastbound at JOBOC and 2 westbound at SLATIN.
Run 2	B	"H" Nothing.
	A	"R" Nights.
	D	"H" None.
	C	"R" No changes.
	(X)	No change.
	(Y)	More aircraft to increase complexity, maybe 4 to 5 more aircraft.
Run 3	B	"H" There was a heavy workload on the "pilot" due to numerous directs which slowed down the problem somewhat.
	A	"R" Nothing.
	D	"H" None.
	C	"R" Simulate traffic on A699 and A700 to block altitude availability. Also, simulate aircraft that are unable FL 310 or higher.
	(X)	No change.

Q6. NE04		
Run 1	A	"H" Less aircraft, clearer communications systems.
	B	"R" Change communication system so "H" can hear pilots. In the real world, BOS wouldn't send aircraft that were in conflict.
	(Y)	More realistic communications would have allowed for much less of a workload on all positions.
Run 2	B	"H" Possibly start switching aircraft from 132.15 (R86 freq.) to 125.92 (R65 freq.) when transmitting sectors.
	C	"R" Try similar traffic situations with all warning areas (W105 and W107) active.
	(X)	Nothing - scenario seemed realistic.
	(Y)	Increase aircraft 3-4 planes.
Run 3	C	"H" Need to simulate unavailability of D72 controller and altitude unavailability because of A699 and A700 traffic.
	A	"R" Keep closer eye on flight climbing to JOBOC.
	(X)	Nothing, simulation was realistic.
	(Y)	More aircraft requesting different altitudes.

Q6. NE05		
Run 1	B	"H" Remove some aircraft.
	C	"R" Split sectors; have aircraft enter sector separated; have ability for "R" to communicate with other sectors, facilities.
	(X)	Remove some of the aircraft. The scenario is not realistic.
Run 2	A	"H" It is not normal for flights to always request higher at a time of receiving the oceanic clearance.
	B	"R" (No comment)
	(X)	No - traffic scenario seemed realistic.
	(Y)	A couple more aircraft.
Run 3	C	"H" No changes.
	A	"R" Bring more airplanes.
	(X)	No changes.
	(Y)	A few more JOBOC aircraft.

Q6. NE06		
Run 1	C	"H" Don't mix RVSM with non-RVSM aircraft.
	A	"R" Issue some oceanic clearances sooner and keep a closer eye on some R86 traffic.
	(X)	Nothing. Scenario seemed actual.
	(Y)	More of a mixture of RVSM and non-RVSM aircraft.
Run 2	A	"H" Nothing.
	B	"R" Nothing.
	(X)	Nothing - traffic scenario was fine.
	(Y)	Three more planes.
Run 3	B	"H" Several aircraft speeds were odd - faster behind when both are similar aircraft types climbing to the same altitudes.
	C	"R" No changes from previous comments.
	(X)	No change.
	(Y)	No changes. Maybe more aircraft departing with RVSM requested.

Q6. Actual		
Run 1	A	"H" Climb rates are slower than normal as are speeds on some aircraft, 200K overtake doesn't occur between jet aircraft.
	B	"R" Reducing the number of aircraft made a much more realistic simulation but aircraft climb rates were too slow, and speed when climbing was too slow which made it unrealistic.
	(X)	Nothing. Scenario was realistic.
	(Y)	Utilize RVSM (this simulation did not).
Run 2	B	"H" Nothing.
	C	"R" Good problem.
	(X)	Nothing. Traffic appeared realistic.
	(Y)	Add RVSM. A good difficult problem.
Run 3	C	"H" Simulate traffic on A699 and A700.
	A	"R" Have all the strips prior to running.
	(Y)	A great exercise. Problems run very accurately and well.

Q6. SW BASE		
Run 1	C	"H" Reroute more aircraft to Boston Center to relieve controller workload.
	A	"R" Speeds are not always properly inserted in the computer to be realistic.
	(X)	Nothing. Scenario was excellent.
	(Y)	Wouldn't change.
Run 2	B	"H" Nothing.
	C	"R" No change from previous comments.
	(X)	No change.
	(Y)	No.
Run 3	A	"H" No.
	B	"R" Nothing.
	(Y)	No changes.

Q6. SW RVSM		
Run 1	C	"H" No change.
	A	"R" It would have been nice to have the warning areas.
	(X)	Nothing. Simulation was very realistic.
	(Y)	One of the best run problems so far.
Run 2	A	"H" We would get all the departure strips.
	B	"R" Split sectors.
	(X)	Nothing. Scenario seemed realistic.
	(Y)	A very busy run. Simulation was a good exercise.
Run 3	B	"H" Climb and descent rates sometimes unrealistic.
	C	"R" No changes.
	(Y)	No changes, good problem.

Q6. SW KENDA		
Run 1	A	"H" (No comment)
	B	"R" Off load some of the JOBOC traffic to the BOS on N14.
	(X)	No. Scenario seemed realistic.
	(Y)	No changes.
Run 2	B	"H" No - except not all the proper strips are being generated.
	C	"R" Sectors should be split.
	(X)	No change.
	(Y)	No changes, good problem.
Run 3	C	"H" Simulate loss of VHF contact between R65 and R86.
	A	"R" Split the sectors.
	(X)	No change.
	(Y)	No changes.

Q6. <u>SW MTT</u>		
Run 1	C	"H" No changes.
	A	"R" (No comment)
	(X)	Nothing. Scenario was realistic.
	(Y)	A good problem. Well run by these controllers.
Run 2	B	"H" Nothing.
	C	"R" Good problem.
	(X)	Nothing. Scenario seemed realistic.
	(Y)	Wouldn't change anything. The problem was very busy but manageable with good control.
Run 3	A	"H" (No comment)
	B	"R" Good speeds off on some.
	(X)	No change.
	(Y)	Good problem.

7. Did you (the controllers) control and work strategies in any way in order to work the traffic with RVSM? If so, how? What did you (they) do differently?

Q7. NE01		
Run 1	A	"H" No.
	B	"R" Nothing.
	C	"H" No - RVSM was not factor in R86 only.
	D	"R" No.
	(X)	Sector 86 was CVSM only. Sector 86 controller was assigning RVSM altitudes through. This is a technical issue that must be resolved. With sectors split R86 controller had time to help out R65 by issuing some of the oceanic clearances.
	(Y)	Just remembering that RVSM altitudes are available.
Run 2	C	"H" No.
	A	"R" No.
	D	"H" No.
	B	"R" No - RVSM wasn't approved for R86.
	(X)	No change in work strategies. R86 did not use RVSM altitudes.
	(Y)	No.
Run 3	B	"H" No.
	A	"R" No.
	D	"H" Yes. When RVSM is canceled, your priority becomes arranging new altitudes for all flights. This only becomes a factor because of 1000 ft separation. This hasn't been a factor with 2000 ft separation.
	C	"R" No change from previous comments.
	(X)	No change. Traffic was controlled as if CVSM.
	(Y)	Not really, the period reverting to CVSM was the biggest effect that occurred during the problems. To complete the reversion it lasted about 10 minutes of busy work.

Q7. NE02		
Run 1	B	"H" No. RVSM not used in R86.
	A	"R" No.
	D	"H" No.
	C	"R" No.
	(X)	No. R86 was not privileged to RVSM separation. R86 controller used CVSM separation and CVSM altitudes.
	(Y)	No. Just to use RVSM.
Run 2	A	"H" No.
	B	"R" Put a J-ball on non-RVSM aircraft that would be a factor later on as a reminder.
	C	"H" RVSM did not apply to this sector.
	D	"R" Aircraft requesting RVSM altitudes got 330 and were told to request higher from 65.
	(X)	No. Controllers did not change any of their work strategies. RVSM did not seem to be an issue in this problem.
	(Y)	No.
Run 3	C	"H" No.
	A	"R" No.
	D	"H" None.
	B	"R" No.
	(X)	No change. Sector did not use any RVSM altitudes.

Q7. NE03		
Run 1	A	"H" No.
	B	"R" No.
	C	"H" No.
	D	"R" No.
	(X)	Yes. "R" Controller used RVSM altitudes for aircraft requesting them.
	(Y)	No.
Run 2	B	"H" No.
	A	"R" No.
	D	"H" No.
	C	"R" No.
	(X)	Yes. "R" controller began by using RVSM altitudes, but then realized he needed CVSM separation with non-RVSM aircraft.
	(Y)	No.
Run 3	B	"H" No.
	A	"R" Never.
	D	"H" No.
	C	"R" No.
	(X)	RVSM had no impact on the sector. Some RVSM altitudes were issued, but had no impact on the sector.
	(Y)	(No comment)

Q7. NE04		
Run 1	A	"H" Not sure.
	B	"R" Had to space transmissions or alternate from R86 to R65 so as to not overload the remotes. The whole process of issuing clearances was made significantly slower.
	(Y)	Basically no except getting used to the communication system.
Run 2	B	"H" No.
	C	"R" Nothing. RVSM possibly reduced my workload because more altitudes were available so there were no minimum in trail pairs (10').
	(X)	No.
	(Y)	No changes noted.
Run 3	C	"H" Added workload to separate RVSM from non-RVSM aircraft over SLATIN.
	A	"R" No.
	(X)	Yes. Controller had to maintain awareness of RVSM aircraft converging with non-RVSM aircraft.
	(Y)	No.

Q7. NE05		
Run 1	B	"H" No.
	C	"R" Did not change work strategies.
	(X)	No. The "H" controller worked at his usual speed. The "R" controller stopped traffic as was expected.
Run 2	A	"H" (No comment).
	B	"R" Nothing. RVSM possibly reduced my work load because more altitudes were available so there were no minimum in-trail pairs (10').
	(X)	No.
	(Y)	No changes noted.
Run 3	C	"H" No.
	A	"R" No.
	(X)	Yes. VIRO76 was assigned FL 320. When aircraft transitioned into R86 airspace, the "R" controller did not reassign a CVSM altitude but simply put 310B330 in data block.
	(Y)	No.

Q7. NE06		
Run 1	C	"H" No.
	A	"R" No.
	(X)	No. Worked as if normal traffic.
	(Y)	No.
Run 2	A	"H" No it's easier.
	B	"R" I waited to give oceanic clearances until an altitude was approved, if there was a question as to what altitudes would be either requested or approved to lower the number of transmissions.
	(X)	No. "R" man worked at usual slow pace.
	(Y)	No.
Run 3	B	"H" No.
	C	"R" Yes. Additional clearances issued to keep RVSM from CVSM traffic.
	(X)	No. RVSM helped the controller, but the controllers usual work strategies were not changed.
	(Y)	No. They could have utilized RVSM and SLATN more effectively.

Q7. Actual		
Run 1	A	"H" Yes, much more vectoring to get in-trail separation.
	B	"R" This was CVSM.
	(X)	N/A CVSM simulation.
	(Y)	RVSM not available this time.
Run 2	B	"H" No.
	C	"R" No changes.
	(X)	"R" controller compensated controlling actions because of inadequacies of "H" controller.
	(Y)	No changes really.
Run 3	C	"H" No.
	A	"R" (No comment)
	(Y)	The problem was CVSM. Compared to RVSM, this problem was very difficult. The problem would have been much easier to run with RVSM.

Q7. SW BASE		
Run 1	C	"H" Yes, FL 310 was approved for southbound aircraft over CHAMP. This is not typical.
	A	"R" No.
	(X)	No. Normal procedures.
	(Y)	Not very natural.
Run 2	B	"H" No.
	C	"R" No.
	(X)	No change in work strategies.
	(Y)	No.
Run 3	A	"H" No.
	B	"R" No.
	(Y)	No.

Q7. SW RVSM		
Run 1	C	"H" No.
	A	"R" No, other than to maintain CVSM separation with Caribbean traffic.
	(X)	Yes. "R" man had to monitor RVSM aircraft in order to keep them separated from non-RVSM aircraft in sector R86. Controller kept on top of the situation.
	(Y)	Not that could be discerned.
Run 2	A	"H" No.
	B	"R" No. All eastbound traffic to JFK descended to 140 anyway.
	(X)	No, controller worked the traffic same as CVSM.
	(Y)	No, it helped them separate airplanes.
Run 3	B	"H" No.
	C	"R" No.
	(Y)	No, they did a very good job.

Q7. SW KENDA		
Run 1	A	"H" No.
	B	"R" No.
	(X)	No. "R" controller did nothing different.
	(Y)	No.
Run 2	B	"H" Tried to coordinate to get altitude approvals as early as possible.
	C	"R" Extra scan of strips and traffic to keep RVSM from CVSM traffic.
	(X)	Yes, "R" controller used all the airspace (R65 and R86) to transition RVSM aircraft to CVSM separation.
	(Y)	No.
Run 3	C	"H" No.
	A	"R" No.
	(X)	No change in work strategies because of RVSM.
	(Y)	No.

Q7. SW MTT		
Run 1	C	"H" No.
	A	"R" No, except to keep CVSM separation from Caribbean traffic.
	(X)	Yes. Controller waited to descend aircraft. There was no concern about establishing CVSM separation. Leaving the aircraft at an RVSM altitude usually allowed one clearance per aircraft for descent. If CVSM would have been required in sector 65, 2 clearances would have been needed for each aircraft. One clearance to a CVSM altitude and then a descend clearance.
	(Y)	No, I don't believe so.
Run 2	B	"H" No.
	C	"R" Extra scan needed to determine which aircraft were exiting airspace to another facility - had to be returned to CVSM.
	(X)	No. RVSM required no change on the part of the controller.
	(Y)	Slight change when offering RVSM to ensure aircraft is tracking into RVSM approved airspace.
Run 3	A	"H" No.
	B	"R" No.
	(X)	No change in work strategy.
	(Y)	No, just more efficient.

8. Based on your experience (observations) with RVSM in the last simulation run, what procedures would have to be changed and/or implemented in order for you (the controllers) to continue to be comfortable about transitioning (working) this traffic?

Q8. NE01		
Run 1	A	"H" Nothing.
	B	"R" RVSM in R86 would help.
	C	"H" R86 must be able to assign RVSM altitudes, and ideally, use RVSM between RVSM-equipped aircraft.
	D	"R" R86/65 split more often.
	(X)	Sector 86 was CVSM only, but "R" controller was issuing RVSM altitudes. This procedure is not per 7110.65. This issue needs to be addressed. If airspace is not RVSM - can controller issue as transition area and assign RVSM altitudes?
	(Y)	Just time.
Run 2	C	"H" No change from previous comments.
	A	"R" R65, 86 should both be RVSM.
	D	"H" No changes.
	B	"R" RVSM in R86.
	(X)	No change in procedures for this sector.
	(Y)	No changes.
Run 3	B	"H" (No comment)
	A	"R" I would like it in both "R" areas.
	D	"H" A little more time in advance if RVSM is going to be canceled. This may not be practical but if possible - great.
	C	"R" Procedures for suspension of RVSM must be clearly defined.
	(X)	No change in procedures in this problem.
	(Y)	A question might be, if one aircraft reports turbulence does it effect all of RVSM airspace? What about aircraft already ahead of the turbulence, etc.? Another question, when RVSM is terminated, due to turbulence in the ocean, can it be used in JOBOC airspace?

Q8. NE02		
Run 1	B	"H" RVSM in R86 to help set up traffic going to R65.
	A	"R" Get rush in all offshore space.
	D	"H" None.
	C	"R" Separate frequency to issue oceanic clearances. Procedures for altitude assignment on track versus random routes need to be developed. A632 traffic interferes with RVSM aircraft.
	(X)	An agreement between 65 and 86 would have to be reached regarding what altitudes eastbound aircraft would be cleared to. Twice, R86 gave 2 aircraft with less than longitudinal spacing the same altitude, assuming 65 was going to climb one of the aircraft to an RVSM altitude.
	(Y)	No changes, RVSM helped this problem.
Run 2	A	"H" Both sectors please.
	B	"R" RVSM in R86.
	C	"H" No changes from previous comments.
	D	"R" None.
	(X)	No procedural changes this time. RVSM played no part in R86 traffic.
	(Y)	No changes.
Run 3	C	"H" Same as previous comments.
	A	"R" Both 65 and 86 should have authority.
	D	"H" None.
	B	"R" RVSM in R86 would have allowed climbs to higher altitudes. There is a possible pilot confusion when one ZNY oceanic transition sector can use RVSM altitudes and the other cannot.
	(X)	No procedural changes. RVSM not used in problem.
	(Y)	No, it's working very well.

Q8. NE03		
Run 1	A	"H" All offshore radar should have it.
	B	"R" Nothing, except maybe BOS transition sectors should be allowed to use RVSM also (since they feed both US and QM).
	C	"H" Same as previous comments.
	D	"R" None.
	(X)	Procedures need to be established regarding separation between RVSM and non-RVSM aircraft.
	(Y)	No changes.
Run 2	B	"H" None.
	A	"R" This scenario worked well.
	D	"H" During eastbound flow, no change.
	C	"R" CVSM aircraft should be at FL 280 or below unless otherwise coordinated. During busy traffic periods, separate frequency for issuing oceanic clearances is necessary.
	(X)	RKA010 was cleared 37N/60W. This required a coordination with D87 (WATRS). This may not be legal.
	(Y)	No changes except develop procedures for mixed aircraft.
Run 3	B	"H" As long as both sectors have it, everything is fine.
	A	"R" Was able to climb aircraft going to R65 to better altitudes.
	D	"H" None.
	C	"R" Same as previous comments.
	(X)	No procedural changes.

Q8. NE04		
Run 1	A	"H" None.
	B	"R" Flow Control.
	(Y)	(No comment)
Run 2	B	"H" Nothing.
	C	"R" Sector R86 and R65 should be split due to need for change of frequency.
	(X)	Nothing, RVSM worked well.
	(Y)	(No comment)
Run 3	C	"H" Non-RVSM aircraft should be altitude restricted in R65 to FL 280 or below, except with prior coordination.
	A	"R" None.
	(X)	Sectors would have to be split due to high workload in short amount of time.
	(Y)	(No comment)

Q8. NE05		
Run 1	B	"H" Sector's split. Less traffic and frequency congestion. Smaller scope range allowing for better traffic picture.
	C	"R" Separate frequency to issue oceanic clearances. Timely approval of altitudes from manual sector on eastbound flow. Less random route traffic. Highlight non-RVSM traffic to separate from RVSM traffic.
	(X)	Traffic management would have to be more involved with managing the flow of traffic through the sector. Training of controllers would have to be of a higher standard. Current controllers in the area working the sector could not handle this traffic.
Run 2	A	"H" None.
	B	"R" None.
	(X)	Sectors would have to be split. Trying to put aircraft in trail and listen to oceanic clearances was too much.
	(Y)	No changes.
Run 3	C	"H" On "H" position, no changes.
	A	"R" None.
	(X)	RVSM transition airspace should encompass sector 86. By having more airspace, it helps the controller and reduces the number of clearances that have to be issued.
	(Y)	None.

Q8. NE06		
Run 1	C	"H" Same as #6. Also, separate frequency to issue oceanic clearances.
	A	"R" One has to be aware of CVSM-only aircraft.
	(X)	There must be a determination made regarding aircraft filed A632, whether they are RVSM/MNPS equipped.
	(Y)	All aircraft should be RVSM qualified.
Run 2	A	"H" Better frequency coverage in the real world would be nice.
	B	"R" Nothing.
	(X)	Again, the determination of whether RVSM can be used with regard to A632 traffic.
	(Y)	(No comment)
Run 3	B	"H" RVSM in R86.
	C	"R" Same as previous comments.
	(X)	No change.
	(Y)	No change works well.

Q8. Actual		
Run 1	A	"H" Monitoring aircraft to ensure separation.
	B	"R" CVSM.
	(X)	N/A CVSM simulation.
	(Y)	RVSM does not make the operation easier.
Run 2	B	"H" CVSM problem.
	C	"R" Obtaining altitudes for aircraft in a timely manner and issuing oceanic clearances. Also concerned about frequency coverage.
	(X)	Controller workload would have been easier because in trails would not have been required.
	(Y)	RVSM would make this problem a lot easier.
Run 3	C	"H" Maintaining appropriate separation.
	A	"R" Getting altitudes approved so I could climb/descend aircraft.
	(Y)	No changes.

Q8. SW BASE		
Run 1	C	"H" Effecting proper coordination with D87 for southbound traffic that would ensure separation.
	A	"R" Trying to keep an orderly flow.
	(X)	Traffic load was OK. RVSM may have increased workload if only available in 65.
	(Y)	A CVSM problem.
Run 2	B	"H" None. Traffic flow was well spaced.
	C	"R" Same as previous comments. Easy problem.
	(X)	No change in procedures.
	(Y)	CVSM.
Run 3	A	"H" (No comment)
	B	"R" Routing some traffic southbound to BERGH A300 US LINND CHAMP - puts them head on with descending northbound traffic to OWENZ.
	(Y)	CVSM problem.

Q8. SW RVSM		
Run 1	C	"H" Need assurance of reliable frequency coverage between R86 and R65 boundary. Need lost communication procedures for all aircraft at RVSM altitudes.
	A	"R" None.
	(X)	Again the issue of separating RVSM aircraft with non-RVSM aircraft. Procedures need to be established to determine what separation standards are to be used.
	(Y)	RVSM may mean more aircraft in the future. Controllers become more competent the more they work with heavier traffic.
Run 2	A	"H" None.
	B	"R" Flow control, possible off loads at JOBOC to N14 routing through BOS.
	(X)	Since there will be more aircraft at the fix at the same time (or possibility thereof), determination of in-trail spacing will need to begin earlier, i.e., in sector 65. In this problem, the "R" controller waited until aircraft were in sector 86, then took control and made sequencing moves.
	(Y)	None.
Run 3	B	"H" RVSM in R86 and R65.
	C	"R" R86 should be allowed RVSM.
	(Y)	Make sure both sector R65 and 86 are RVSM sectors.

Q8. SW KENDA		
Run 1	A	"H" None.
	B	"R" We need RVSM on R86 to allow more time and space to get things accomplished.
	(X)	No procedures would have to change.
	(Y)	None.
Run 2	B	"H" Need RVSM in both sectors.
	C	"R" RVSM authority should extend to R86.
	(X)	Both sectors would be used (as in this problem) to use RVSM separation.
	(Y)	RVSM helped this problem a lot.
Run 3	C	"H" Same as previous comments.
	A	"R" This was good to get RVSM in both sectors.
	(X)	No procedural change.
	(Y)	RVSM available in both 65/86.

Q8. SW MTT		
Run 1	C	"H" frequency coverage not simulated but very important. Sectors R86 and R65 should be split with this volume of traffic.
	A	"R" None.
	(X)	If traffic was really this busy, some type of traffic flow procedures would have to be established to handle this flow of traffic.
	(Y)	It's really working well in these problems.
Run 2	B	"H" Nothing (except we need RVSM in 86 as well as 65 to allow to do everything).
	C	"R" Need R86 for transition airspace.
	(X)	None. RVSM played no factor.
	(Y)	No.
Run 3	A	"H" Last run was fine.
	B	"R" RVSM in both R86 and R65.
	(X)	No change to procedures.
	(Y)	RVSM in both R65/R86.

9. What was your primary safety concern considering traffic, events, and procedures in the last simulation run?

Q9. NE01		
Run 1	A	"H" Normal stuff.
	B	"R" Nothing not mentioned early.
	C	"H" No major concerns.
	D	"R" None concerning RVSM. Traffic density led to data block overlap at times.
	(X)	No safety concerns, traffic flowed smoothly.
	(Y)	(No comment)
Run 2	C	"H" Same as previous runs.
	A	"R" (No comment)
	D	"H" No safety concerns.
	B	"R" None.
	(X)	No change in procedures for this section.
	(Y)	No difficulties.
Run 3	B	"H" None.
	A	"R" Just the normal stuff.
	D	"H" The aircraft that were terminated prior to JOBOC of RVSM altitudes. Sometimes the ARINC frequencies aren't that good between 67 and 65W. I guess 72 would have to do the best he can.
	C	"R" No change from previous comment.
	(X)	No safety concerns.
	(Y)	Reverting to CVSM.

Q9. NE02		
Run 1	B	"H" Nothing.
	A	"R" (No comment)
	D	"H" Getting all oceanics issued/entered in computer before aircraft get to coast - out fixes.
	C	"R" Ensuring longitudinal separation between RVSM and CVSM aircraft.
	(X)	No safety concerns. Sector was not overloaded with traffic or data blocks.
	(Y)	Frequency congestion.
Run 2	A	"H" (No comment)
	B	"R" None.
	C	"H" No concerns for this traffic scenario.
	D	"R" None.
	(X)	No safety concerns. Traffic flowed smoothly, RVSM not an issue.
	(Y)	Easy problem.
Run 3	C	"H" No changes from previous comments.
	A	"R" The normal stuff.
	D	"H" No special safety concerns.
	B	"R" None.
	(X)	No safety concerns. All aircraft well separated.
	(Y)	No safety concerns. Problem was well run, and controlled almost perfectly.

Q9. NE03		
Run 1	A	"H" (No comment)
	B	"R" None.
	C	"H" Same as previous comments.
	D	"R" Errant turns by flights; strange speeds. Just ensuring aircraft do as instructed.
	(X)	No real safety problems.
	(Y)	No safety concerns.
Run 2	B	"H" Nothing.
	A	"R" Nothing in particular.
	D	"H" No particular safety concerns.
	C	"R" Maintaining approved separation between RVSM and CVSM aircraft.
	(X)	Major safety concern was keeping RVSM and non-RVSM aircraft separated. By having sector 86 as RVSM authorized, this allowed the "R" controller the ability to use RVSM altitudes. Unfortunately there were non-RVSM aircraft in the sector.
	(Y)	No problems.
Run 3	B	"H" None.
	A	"R" No concerns.
	D	"H" No special concerns.
	C	"R" Same as previous scenarios.
	(X)	Primary safety concerns was the "R" man keeping aircraft separated. Vectors were issued to separate but created other situations. These situations were resolved with directs. This created other situations.

Q9. NE04		
Run 1	A	"H" None.
	B	"R" Due to data block overlap, frequency overload, and strip volume, the possibility of losing the radar picture.
	(Y)	Frequency congestion.
Run 2	B	"H" Nothing.
	C	"R" Maintaining separation between RVSM and non-RVSM aircraft.
	(X)	No real safety concern. Traffic was handled well by "R" controller.
	(Y)	Frequency congestion, ensuring simulation ran smoothly.
Run 3	C	"H" RVSM separation from non-RVSM (see #7).
	A	"R" Nothing out of the norm.
	(X)	Controllers attention was diverted from pending situation due to other events occurring in another sector of the combined sectors.
	(Y)	Operational error due to the large amount of planes.

Q9. NE05		
Run 1	B	"H" Traffic on A632 is not RVSM approved. During heavy traffic conditions, this could be easily forgotten especially on southbound/ eastbound traffic since all the aircraft are going in the same general direction. Not enough time to issue oceanic clearances to JOBOC traffic due to the shared amount of time they are in the sector. Data block overlap causing loss of target identity and inability to see altitude data.
	C	"R" Issuing oceanic clearances and assigning approval altitudes. Coordination and strip marking were ignored for the most part.
	(X)	The primary concern was taking hand-offs on aircraft that are head-on.
Run 2	A	"H" Just keeping them separated.
	B	"R" Nothing.
	(X)	Primary concern was ensuring aircraft had correct oceanic clearances. R man at times was not checking read backs. This could cause a problem later on.
	(Y)	No real concerns.
Run 3	C	"H" Assisting radar controller in ensuring proper longitudinal spacing for eastbound traffic.
	A	"R" (No comment)
	(X)	No real safety issues to concern ourselves with. Traffic was always kept in a safe, expeditious flow.
	(Y)	None.

Q9. NE06		
Run 1	C	"H" Maintaining separation between RVSM and non-RVSM aircraft.
	A	"R" Just doing my job.
	(X)	RVSM versus non-RVSM equipped aircraft.
	(Y)	Separating RVSM aircraft from non-RVSM aircraft.
Run 2	A	"H" Same as it ever was.
	B	"R" MISSING
	(X)	None really. There was no problem with safety.
	(Y)	No major problems.
Run 3	B	"H" None.
	C	"R" Same as previous comments.
	(X)	No safety concerns, traffic ran smoothly.
	(Y)	Separation of aircraft.

Q9. Actual		
Run 1	A	"H" MISSING
	B	"R" Getting altitude approvals in a timely manner from D72. In the real world, a few aircraft would probably have been waiting for approvals.
	(X)	The "R" controller awareness of what was occurring. "R" controller seemed behind at all times. Excessive vectoring resulted in situations that required additional clearances to maintain separation.
	(Y)	Finding available altitudes.
Run 2	B	"H" Too busy to remain aware of center versus actual times (JOBOC and SLATIN).
	C	"R" MISSING
	(X)	By terminating radar early, the controllers were not aware of aircraft in the sector.
	(Y)	A lot of difficulty for H and oceanic controller. A group problem.
Run 3	C	"H" MISSING
	A	"R" MISSING
	(Y)	No safety concerns. In future simulations, more comparisons to the difficulty experienced on the floor.

Q9. SW BASE		
Run 1	C	"H" MISSING
	A	"R" MISSING
	(X)	No safety concern. Problem was run fine.
	(Y)	A busy well run problem.
Run 2	B	"H" MISSING
	C	"R" MISSING
	(X)	No safety concerns.
	(Y)	None.
Run 3	A	"H" MISSING
	B	"R" MISSING
	(Y)	Separation during heavy point.

Q9. SW RVSM		
Run 1	C	"H" Frequency coverage (see #8).
	A	"R" Maintain data block separation.
	(X)	The primary safety concern was keeping RVSM aircraft separated from non-RVSM aircraft. The R controller had to keep on top of these aircraft.
	(Y)	Just trying to keep up with the heavy traffic.
Run 2	A	"H" Normal procedure.
	B	"R" Being aware of what frequency a westbound flight is on and switching from 125.92 to 132.15 in time (or the aircraft may become NORDO "no radio").
	(X)	My primary safety concern was keeping aircraft separated. Many times data blocks overlapped and I could not see what altitudes the aircraft were at.
	(Y)	Spacing to JFK.
Run 3	B	"H" None.
	C	"R" Maintaining longitudinal spacing for southbounds and for JFK arrivals.
	(Y)	A lot of planes, safety concern was just ensuring separation.

Q9. SW KENDA		
Run 1	A	"H" Separation from warning areas.
	B	"R" With splitting my attention between radar identifying, deciding sequencing, vectoring, monitoring aircraft descending into OWENZ for separation (since the spacing is so close), losing the traffic picture, or overloading a situation.
	(X)	In trail. R controller issued many vectors to retain in-trail operation. These vectors compounded the separation problem.
	(Y)	Keeping aircraft from running into each other, airspace, and spacing to JFK.
Run 2	B	"H" Frequency, congestion, and too many airplanes. Hard to keep up with all the different impending situations.
	C	"R" Same as previous comments.
	(X)	No safety problem. Aircraft flow was maintained, and separation not a problem.
	(Y)	Controllers situational awareness and scan became a little shaky towards end of problem. Little help from H controller.
Run 3	C	"H" Same as previous comments.
	A	"R" Just keeping my head above water.
	(X)	No safety problems.
	(Y)	Maintaining control in a very busy problem. That means staying ahead of traffic conflicts and crossing traffic problems. RVSM helped in both categories.

Q9. SW MTT		
Run 1	C	"H" Use of warning areas allowed greater flexibility for sequencing traffic via OWENZ and CAMRN. Without warning areas, situations would be more chaotic. Lost communications with RVSM aircraft would cause significant workload increase for R86.
	A	"R" Keeping traffic and data blocks separated.
	(X)	Too many data blocks created overlapping data. Conflict alert would have been the only way potential conflicts are observed.
	(Y)	Controller needed to maintain a high awareness to run smoothly. Controllers did well.
Run 2	B	"H" Nothing.
	C	"R" Using RVSM among aircraft and not CVSM aircraft. Similar sounding call signs in this scenario could be deadly.
	(X)	Safety was never a problem. "R" controller took appropriate actions to separate aircraft.
	(Y)	Spacing to JFK, maintaining separation.
Run 3	A	"H" The normal stuff.
	B	"R" Frequency, congestion causing a delay in issuing clearances.
	(X)	No real safety concerns. Traffic management was okay.
	(Y)	Separating traffic.

APPENDIX D
ACRONYMS AND GLOSSARY

ACRONYMS

ANOVA	ANalysis Of VAriance
ARINC	Aeronautical Radio Incorporated
ARTCC	Air Route Traffic Control Center
AT	Air Traffic
ATC	Air Traffic Control
ATWIT	Air Traffic Workload Input Technique
BOS	General Edward Lawrence Logan International Airport
CRD	Computer Readout Display
CVSM	Conventional Vertical Separation Minima
DART	Data Analysis and Reduction Tool
DYSIM	Dynamic Simulation
E	East
FAA	Federal Aviation Administration
FL	Flight level
FPL	Full Performance Level
FT	Feet, foot
H	Hand-off Position
HF	High Frequency
ICAO	International Civil Aviation Organization
m	Meters
MASPS	Minimum Aircraft System Performance Specification
MNPS	Minimum Navigation Performance Specification
MTT	Minimum Track Time
N	North
NAT	North Atlantic
NORDO	No Radio
NSC	National Simulation Capability
ODAPS	Oceanic Display and Planning System
R	Radar
RGCSP	Review of the General Concept of Separation Panel
RTS	Robert Thomas Smith
RVSM	Reduced Vertical Separation Minima
S	South
SAR	System Analysis and Recording
SIM	Simulated
T/O	Technical Observer
TWR	Tower
US	United States
VHF	Very High Frequency
VHS	Video Home System
VSM	Vertical Separation Minimum

W	West
WATRS	Western Atlantic Track Route System
ZBW	Boston ARTCC
ZNY	New York ARTCC

GLOSSARY

R65/R86	Sector name
310B330	Block altitude from FL 310 to 330
7110.65	FAA Air Traffic Controllers Handbook
A300	Airway
A632	Airway
A699 and A700	Airway
ACT-540	Systems Simulation and Integration Branch
AFS-400	Flight Standards
ARD-20 and ARD-100	Research and Development Service
ASD-400	Program Analysis Operations Research Division
ATM-100	Air Traffic System Management
ATP-100	Air Traffic Rules and Procedures Service
ATP-140	International Procedures Branch
ATR-300	Air Traffic Plans and Requirements Service
BERGH	Fix Name
CAMRN	Fix Name
CHAMP	Fix Name
D72	Sector name
EUROCONTROL	France, The Federal Republic of Germany, Netherlands, and United Kingdom
Host	Host Computer
JOBOC	Fix Name
KENDA	Fix Name
LINND	Fix Name
N14	Track
OTIS	Air Force Base
OWENZ	Fix Name
QM	Fix Name - Moncton
RGCSP/6	Sixth Meeting
SLATN	Fix name
VIRO76	Aircraft ID